Canadian Organic Science Conference

Organic Science Cluster Strategic Meetings

Conference Proceedings

February 21 - 23, 2012
Winnipeg, Manitoba

www.oacc.info/cosc

Proceedings of the Canadian Organic Science Conference and Science Cluster Strategic Meetings

Winnipeg, Manitoba

February 21-23, 2012

Foreword

Welcome to the Canadian Organic Science Conference and Organic Science Cluster Strategic Meetings, the premier exposition of organic research in Canada! Never before have so many Canadian scientists focused on organic agriculture gathered in one place. Aside from the main conference, the program also features invited speakers from the U.S. and Europe, and will conclude with a full day strategic planning session for the future of organic research in Canada. This three day event will serve as an important hub that will connect participants to innovation in organic agriculture.

This event is part of the Canadian Organic Science Cluster, a national initiative in strategic research in organic agriculture. Within this Cluster, scientists across the country are working towards addressing the challenges and capturing the opportunities that currently face organic in Canada. The conference is financially supported by industry partners, from across the country, which have helped to leverage funds from AAFC's Agri-Science Cluster Initiative. With the support of the Organic Federation of Canada, the Organic Agriculture Centre of Canada and the University of Manitoba are very pleased to bring this event to you.

Located at the forks of the Red and Assiniboine Rivers, Winnipeg has been a gathering place for over 6,000 years. We are happy that you were able to join us in snow-sparkled Winnipeg as we gather to share ideas and engage in the science of organic agriculture in Canada.

Sincerely,

Dr. Andy Hammermeister
Conference Co-chair
Director, OACC
Assistant Professor, Nova Scotia Agricultural College

Dr. Martin H. Entz
Conference Co-chair
Professor of Agronomy and Cropping Systems, University of Manitoba

Acknowledgments & Funding Partners

This conference was organized as part of the Organic Science Cluster, a part of the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework, with funding from the following partners within the Organic Science Cluster. *Growing Forward*, a federal-provincial-territorial initiative.

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Province of Ontario

Serres Jardins-Nature

Home Hardware

Les Fraises de l'île d'Orléans, Inc.

Les Serres Lefort, Inc.

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Western Ag Innovations

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Ontario Sheep Marketing Agency

Canadian Seed Breeders Association

Grain Millers Canada

British Columbia New Varieties Development Council, Organic Division

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Homestead Organics

Prairie Oat Growers Association

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Nova Scotia Agricultural College

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University of Guelph

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Nova Scotia Agricultural College

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Margaret Savard
Organic Agriculture Centre of Canada

Iris Vaisman
University of Manitoba

Editors:
Joanna MacKenzie
Margaret Savard

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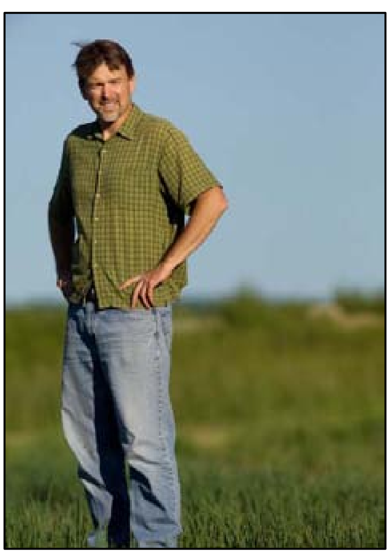
Keynote and Invited Speakers

Dr. Céline Boutin, Environment Canada
Céline Boutin has been working at Environment Canada since 1988, serving as a research scientist since 1997. The overarching goal of her work is to improve risk assessment and refine our knowledge of biodiversity related to the effects of cumulative risk on ecosystem sustainability and resilience. As such, Céline's research integrates a variety of approaches and directions so as to fulfill several distinct objectives. A large part of her time has been devoted to developing and improving tools for pesticide risk assessment. Another aspect of Céline's work has been devoted to investigating changes and decline in biodiversity in agroecosystems. Through the course of her work, Céline has become an adjunct professor at Carleton University and published 90 scientific articles. In her down time, Céline is an enthusiastic road cyclist and likes to travel around the world with her husband to explore natural sites for bird watching and flora observation!

Dr. Kathleen Delate, Iowa State University
Kathleen's current position as Professor at Iowa State University is a joint position between the departments of Horticulture and Agronomy, where she is responsible for research, extension and teaching in organic agriculture. She was awarded the first faculty position in Organic Agriculture at a Land Grant University in the United States in 1997. She has a B.S. in Agronomy and an M.S. in Horticulture from the University of Florida, and a Ph.D. in Agricultural Ecology from the University of California-Berkeley. She has farmed organically in Iowa, California, Florida and Hawaii.



Dr. Eric Gallandt, University of Maine
Eric Gallandt, Weed Ecologist at the University of Maine, works on the ecology and management of annual weeds in organic farming systems. In the early 1990's his research in potato cropping systems demonstrated that potato grown in an amended, high quality soil contributed to weed management by improving potato vigor and thus, interspecific competition with weeds. This inspired a plan of work focused on soil-improving practices and resultant soil quality effects on weed dynamics, including weed-crop competition, seed predation and decay, and weed establishment. His guiding philosophy, described in the 1997 review "Many Little Hammers: Ecological Management of Crop-Weed Interactions," is that progress in weed management requires a systems perspective, stressing weeds at multiple points in their life cycle. Currently his research group is working on improving physical weed control for small-scale growers, sources of variability in cultivation efficacy, landscape effects on weed seed predation, and qualitative research on organic farmers' beliefs and perceptions related to weeds and weed management.

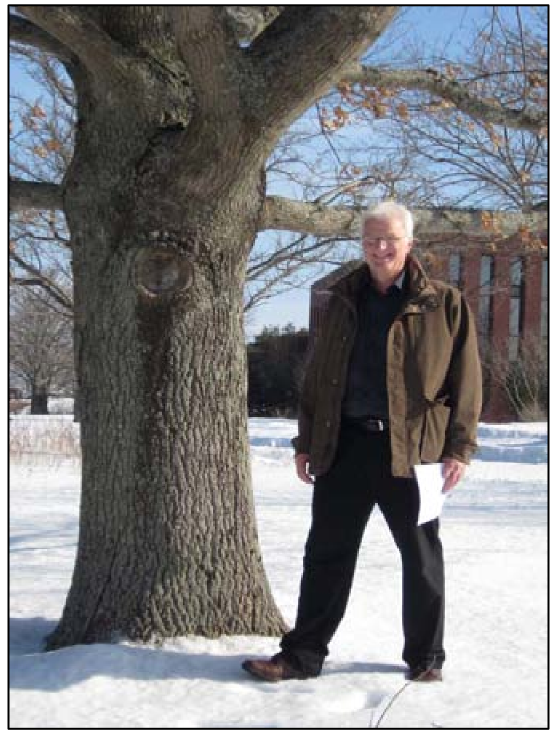
Dr. Frank Kutka, North Dakota State University

Frank Kutka grew up on a hobby farm in southern Wisconsin, studied biology at the University of Wisconsin at Whitewater, ecology at Iowa State University, and plant breeding at Cornell University. He has been a member of the Minnesota Sustainable Farming Association, the New York Chapter of the Northeastern Organic Farming Association, and the Northern Plains Sustainable Agriculture Society based in North Dakota. Frank's duties for North Dakota State University include managing the USDA Sustainable Agriculture Research and Education program as the Extension State Sustainable Agriculture Specialist and as Assistant Director of the Dickinson Research and Extension Center. He also teaches crop production and weed science under contract with Dickinson State University and serves as an Administrative Manager for the Farm Breeding Club under contract with NPSAS.

Dr. Derek Lynch, Nova Scotia Agricultural College

Derek Lynch Ph.D., M.Sc. P. Ag., is an Associate Professor at the Nova Scotia Agricultural College, in Truro, Nova Scotia and has also served, since 2005, as Canada Research Chair (CRC) in Organic Agriculture. Derek's CRC research program in organic agriculture and assessing the environmental impact of these distinctive farming systems, has led to the publication, to date, of over 35 peer-reviewed manuscripts and graduate theses. Some of the most rewarding and productive aspects of his CRC research has been conducted in partnership with organic farmers on commercial farms throughout eastern Canada; providing tremendous additional learning opportunities to graduate students. His other teaching and research interests include nutrient cycling in agro-ecosystems, soil organic matter dynamics, composting and management of manures and organic wastes, soil microbiology, and legume physiology. Nationally, Derek has been very involved in the development of the new Canadian standards for organic agriculture. He also served two terms as Eastern Director of the Canadian Society of Agronomy. Internationally, in recent years Derek has participated in projects related to improving organic and low input farming systems in Gambia and Nepal. He is currently chair of the Research and Innovation Working Group of the National Organic Value Chain Round Table.

Dr. Ralph C. Martin, University of Guelph



Ralph C. Martin Ph.D., P.Ag., grew up on a beef and hog farm in Wallenstein, ON. He learned what is essential about agriculture from his grandfather before he died when Ralph was seven. After 4-H, his formal education includes a B.A. and M.Sc. in Biology from Carleton University and a Ph.D. in Plant Science from McGill University. His love of teaching grew unexpectedly when he began teaching at the Nova Scotia Agricultural College in 1990 and realized how students teach him too.

In 2001, he founded the Organic Agriculture Centre of Canada to coordinate university research and education pertaining to organic systems across Canada. He notes it was a pleasure to work with a great team at OACC and with so many engaged practitioners in the organic sector. Ralph has respect for all the organic businesses that stepped up to provide funding for the Organic Science Cluster in order to leverage AAFC funds and for all researchers who have given so much of their time to this significant development in organic research. In 2011, he was appointed as Professor and the Loblaw Chair in Sustainable Food Production at OAC, University of Guelph.

Dr. Urs Niggli, FiBL Switzerland

Urs Niggli is Executive Director of the Research Institute of Organic Agriculture (FiBL) in Switzerland since 1990. As such, he is responsible for strategic planning and positioning, overall scientific co-ordination and the fundraising of FiBL. FiBL employs 135 scientific and technical staff in Switzerland (Frick, Canton of Aargau), 20 scientific staff in Germany (Frankfurt) and 18 in Vienna (Austria). The three FiBLs are non-governmental research institutes which have expanded their expertise into all fields of organic food and farming research and dissemination.

Urs Niggli's professional background is that of a crop scientist with a Ph.D. in weed management at ETH Zurich. As Honorary Professor, he teaches selected topics of sustainable agriculture and organic farming at the University of Kassel in Germany. He also lectures organic farming at ETH Zurich. Urs Niggli had served for many years on scientific or advisory boards of different research institutions in Germany, Denmark, Switzerland and Austria. From 2008 to 2011, he was on the World Board of the International Federation of Organic Agriculture Movements (IFOAM). He was organizer of the 13th International Scientific IFOAM Conference in Basel (2000) with 1200 participants, initiated the foundation of the International Society of Organic Farming Research (ISOFAR) and is on the Board of several private organic research institutes (Luxemburg, Czech Republic, Hungary, India, Albania). Between 2004 and 2010, he was Academic co-ordinator of the EU-Project QualityLowInputFood with 30 institutes in 13 countries (18 million €). He has published 200 papers in scientific journals, in conference proceedings and books.

Laura Rance, Journalist
Laura Rance is an award-winning journalist who has been reporting on farm and rural issues in Prairie Canada since the early 1980s. Raised on a mixed grain and livestock farm in southern Manitoba, she was introduced to concepts of sustainable agriculture and ethical farming at an early age when her family became one of the first on the eastern Prairies to practice zero tillage. She has combined a lifelong interest in agriculture with her career in journalism to provide news and analysis to the farming community through her current role as editor of the Manitoba Co-operator. As a freelance business columnist for the Winnipeg Free Press, Laura also works to familiarize urbanites with rural and farming issues. Her writing and photography have been recognized by her peers both nationally and internationally. Laura lives on a rural acreage she shares with her daughter near Carman, Manitoba.

Keri Sharpe, Alberta Agriculture and Rural Development
Keri Sharpe has been with Alberta Agriculture and Rural Development since 2003 as the organic business development specialist, based in Stony Plain, Alberta. She has a M.Sc. in Rural Sociology and Business from the University of Alberta. Keri has a strong background in both business diversification and development. She has enjoyed working with Alberta and Prairie organic growers and processors to improve their business opportunities.

Gunta Vitins, Vitins Consulting
Gunta Vitins, B.Sc.(agr), B.Ed, M.B.A., has been spearheading innovative agri-food initiatives in the public and private sectors for over 25 years, focusing on the organic industry for the past two decades. Her work experience spans government, academia, international business and trade, agricultural production, processing, distribution, sales and marketing.

In 1991, Gunta joined the BC Ministry of Agriculture, Fisheries and Food as the Manager of Market Development where she worked on the development and implementation of the Buy BC Program, the BC Certified Organic Program and various federal/provincial initiatives. In 1998, Gunta joined Pro Organics, Canada's leading distributor of organic produce, where she held progressively responsible positions from Sales and Marketing Manager to Vice President of Marketing. Gunta served as V.P. Marketing for Pro Organics from 2004 – 2010 and from 2007 – 2010, held the dual position of Director of Public Relations for SunOpta, Pro Organics' publicly traded parent company and the world's largest organic ingredient supplier. SunOpta had over 70 facilities worldwide involved in sourcing, manufacturing and distributing organic and natural foods. Gunta's experience also includes various national and international speaking engagements and active roles on Agriculture and Agri-Food Canada's Organic Value Chain Roundtable as the Industry Co-Chair and the Chair of the Market Development Working Group, as President of the Canada Organic Trade Association and Executive Board Member (VP Canada) of the Organic Trade Association. Gunta received the Canadian Health Food Association's Organic Achievement Award in 2007 and the Certified Organic Associations of British Columbia's Founders Award in 2005 in recognition of her dedication to the Canadian organic sector.

Plenary Panel: Fostering Farmer-Researcher Collaboration

With Martin Entz, Joanne Theissen Martens, Iris Vaisman and Harun Cicek, the University of Manitoba; Dan and Fran DeRuyck, Top of the Hill Farm; Marvin J. Dyck, Kroeker Farms; moderated by Laura Telford

Martin Entz

Martin Entz is professor of Natural Systems Agriculture at the University of Manitoba. Martin has a M.Sc. in horticulture (University of Manitoba) and a Ph.D. in whole plant physiology and water relations (University of Saskatchewan). He teaches courses in Agroecology, Forage and Pasture Management and Organic Crop Production, and has an active graduate student program. Martin's research focuses on organic cropping systems with specialization in crop rotation and long-term studies. Martin has a long-time interest in self-regenerating farming systems and has spent two sabbatical leaves studying the wheat-sheep system in southern Australia. Martin collaborates with AAFC scientists at Indian Head, SK on a medic cropping system based on the Australian design. Martin also conducts research on crop-livestock integration and organic crop breeding (in collaboration with AAFC scientists). Martin participates in ecologically-integrated farming system development work in North Korea, Central America and China. Martin and his wife and two children operate "Maple Lane shared family farm".

Joanne Theissen Martens

Joanne grew up on a small mixed farm at Austin, Manitoba. She earned a B.Sc. in Agroecology at the University of Manitoba in 1999 and has since been working in the area of organic and sustainable agriculture. For much of this time, Joanne has been a part of Dr. Martin Entz's research team in the Department of Plant Science at the University of Manitoba. She also spent three years assisting small-scale organic market gardeners in north-eastern Brazil and has worked with the Organic Agriculture Centre of Canada as a research and extension associate. Her recent areas of focus include cover cropping and integrated crop-livestock systems.

Iris Vaisman

I was born in Haifa, Israel and grew up in Toronto, Ontario. After completing an Ecology degree at the University of Toronto, I became very interested in agroecosystems. I spent a summer at OACC in Truro, Nova Scotia working as a summer student and getting introduced to the world of organic agriculture. I then did my Masters' degree with Dr. Martin Entz at the University of Manitoba, studying the use of the roller crimper as a way to reduce tillage in organic agriculture. After finishing my M.Sc., I continued working with Dr. Entz on the organic wheat and oat breeding programs, developing varieties for organic systems. I have also worked on the participatory wheat breeding program, where we collaborated with farmers to develop varieties. Currently, I am a technician at the University of Manitoba working for Dr. Yvonne Lawley, focusing on cover crops.

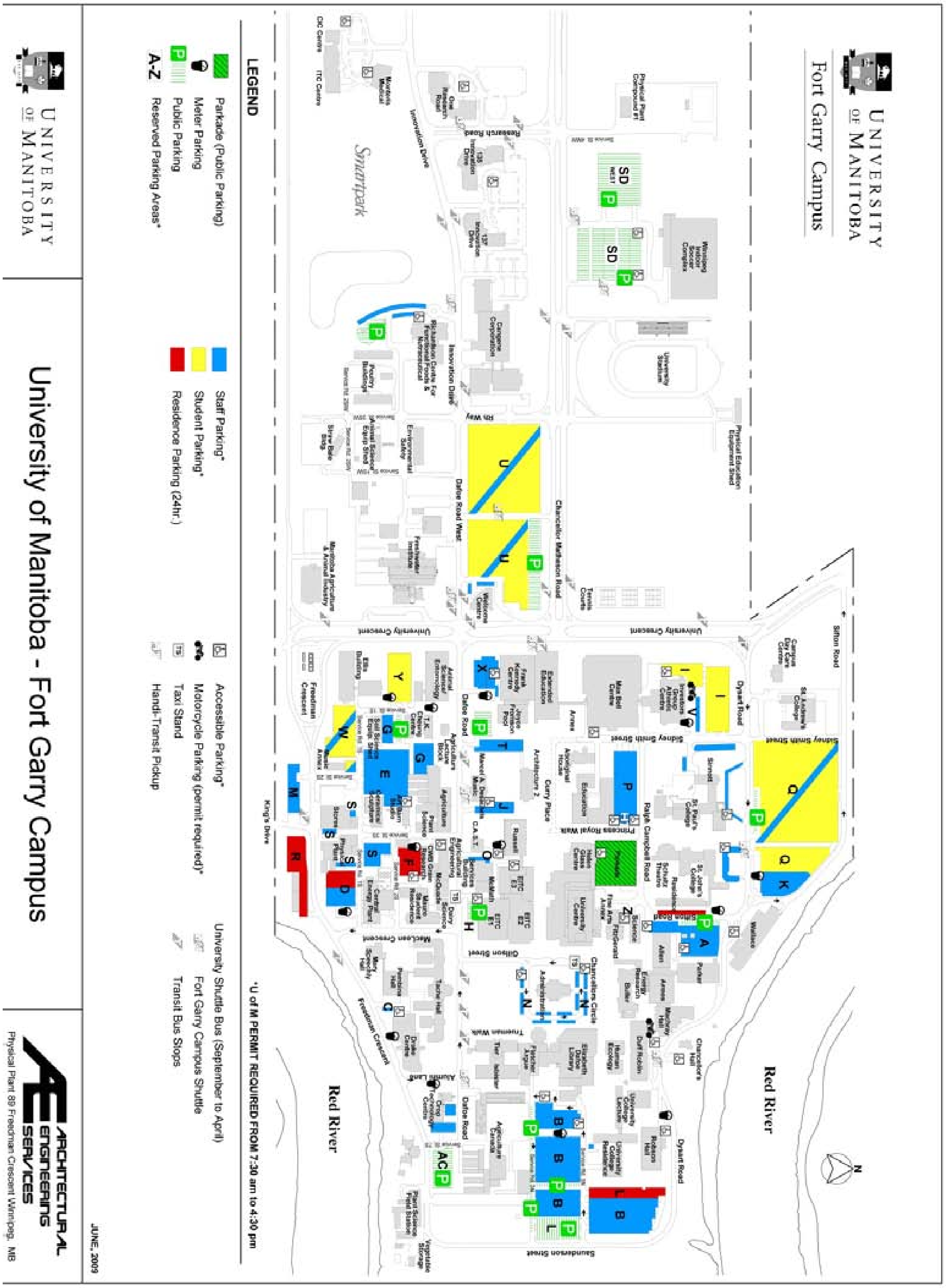
Harun Cicek
I studied Environmental Science at University of Ottawa and realized that food and agriculture related issues were the most important issues facing humankind. Volunteering with Canadian Organic Growers during my undergrad years helped me to further appreciate the organic community and its hard work. Luckily, I found Dr. Martin Entz to supervise and mentor me for my graduate work on cover crops and grazing. I am looking forward to finishing my degree and working with organic producers and consumers.

Dan and Fran DeRuyck
We are Dan & Fran DeRuyck from DeRuyck's Top of the Hill Farm. We live in the Tiger Hills, close to Treherne, Manitoba. We have four grown children and three grandchildren. We have been certified organic farmers since 2006 and along with Dan's parents, do value added processing of our local and farm grown grains into flours and flakes. We also have organic grass-fed cattle. We have hosted farm tours and have done several speaking engagements at schools. Having completed a Holistic Management Course and being members of the Harvest Moon Local Food Initiative, we know the value of education and enjoy sharing the knowledge we gain.

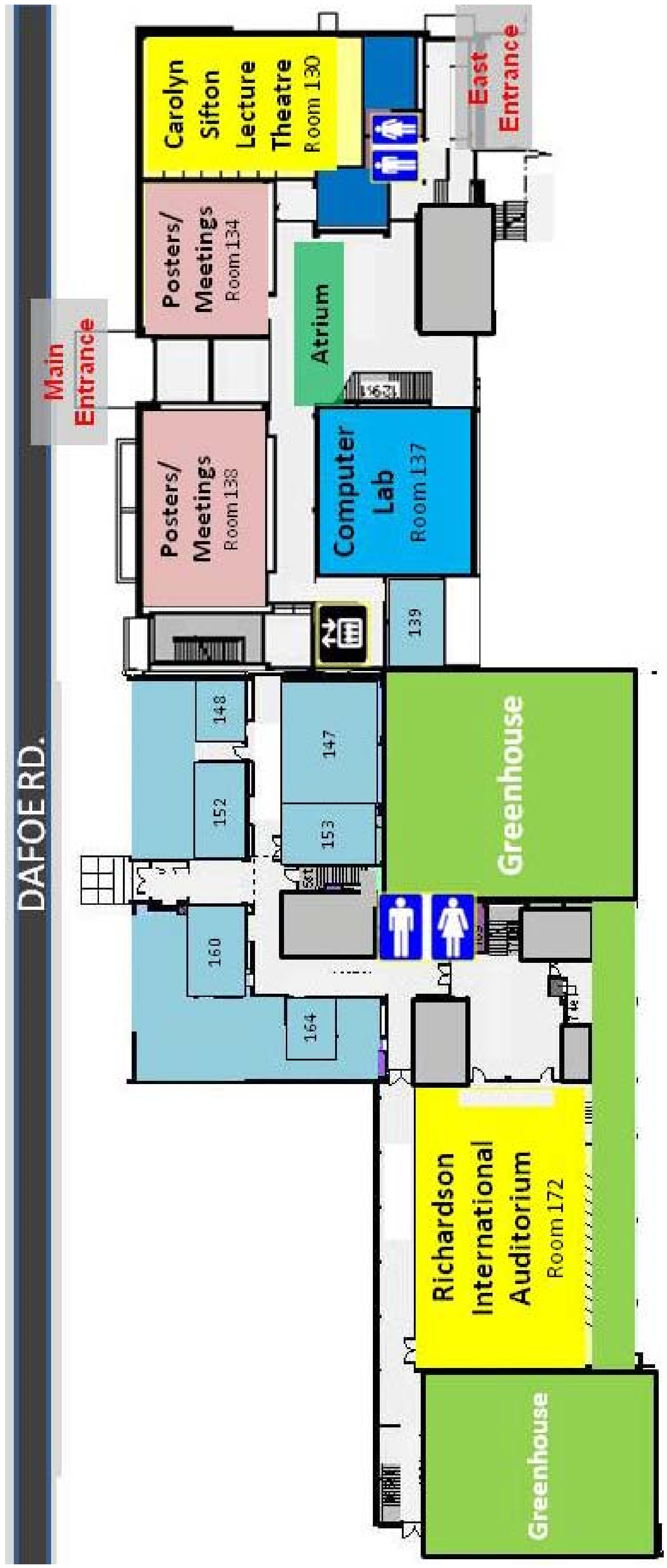
Marvin J. Dyck
I farm in the Winkler area in southern Manitoba. I have been involved with organic farming and Poplar Grove Farm since its beginnings in 2000. I am involved in the areas of Agronomy, Quality Assurance and Certification. In the past I have worked in R&D with an Ag chemical company. I am a graduate with a Bachelor in Agriculture Sciences from the University of Saskatchewan. Our first organic commercial crop was harvested in 2002, with 21 acres of potatoes. At present we organically farm about 2300 acres, producing potatoes, onions, hemp, corn, cabbage, broccoli, carrots, cauliflower, wheat, rye, oats, peas, and beets. Every year about a third of our land base is in green manure or alfalfa.

Laura Telford
Laura Telford recently joined MAFRI (Manitoba Food and Rural Initiatives) as the organic marketing specialist, based at the Food Development Centre in Portage la Prairie. Prior to this, Laura spent eight years as Executive Director of Canadian Organic Growers in Ottawa. She has a Ph.D. from Queen's University in Psychology and spent 7 years conducting research in the field of Neuroscience prior to leaving academia to pursue her environmental interests. Laura has a strong background in both policy and advocacy and she is looking forward to working with Prairie growers and processors to help them improve their markets and profitability.

University of Manitoba Fort Garry Campus



University of Manitoba – Agriculture Building #38



Canada's Organic Science Cluster

Canada's Organic Science Cluster (OSC) is a collaborative effort led jointly by the Organic Agriculture Centre of Canada (OACC) at the Nova Scotia Agricultural College and the Organic Federation of Canada (OFC). The Organic Science Cluster is part of the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and is supported by contributions from industry partners.

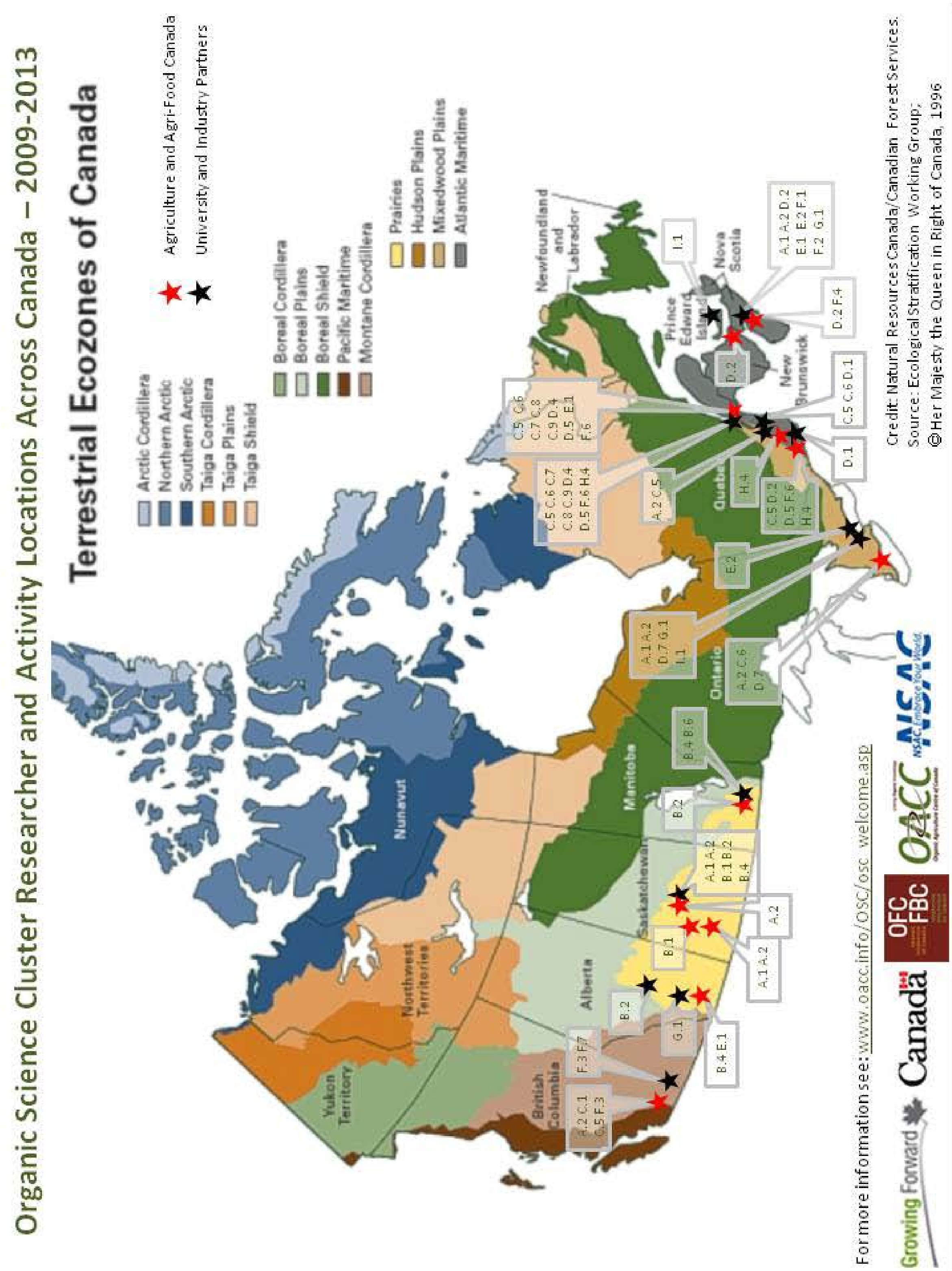
The goals of the Organic Science Cluster are to facilitate a national strategic approach to organic science in Canada, link scientists across the country and disseminate the knowledge generated to organic stakeholders.

The Organic Science Cluster has identified 10 sub-projects including 30 research activities that will be conducted by over 50 researchers plus 30 collaborators in approximately 45 research institutions. Activities of the Organic Science Cluster include work in fruit horticulture, agronomy, cereal crop breeding, soil fertility management, vegetable production, greenhouse production, dairy production systems, parasite control in ruminants, environmental sustainability, and food processing. This research comes at a time when there is renewed emphasis on innovation, efficiency (energy, labour, economics), and capturing value-added markets. Most of this research directed toward organic agriculture can also be applied to conventional production systems, drawing interest to this cluster from producers across Canada.

The Organic Agriculture Centre of Canada is responsible for overseeing the operation of the Organic Science Cluster, including management tasks such as the management of financials, reporting and fundraising, and communications.

For more information on the Canadian Organic Science Cluster, please visit:
http://www.oacc.info/osc/osc_welcome.asp

Organic Science Cluster Map



Organic Science Cluster Research Activities

Subproject A: Biologically-Based Fertility Management

Activity A.1: Characterizing soil phosphorus dynamics and availability under organic crop production
Activity A.2: Predictive tools for characterizing mycorrhizal contributions to phosphorus uptake by organic crops

Subproject B: Integrated Grain-Based Cropping Systems

Activity B.1: Changing weed populations under long-term organic crop production
Activity B.2: Organic cereal crop breeding
Activity B.4: Low-tillage grain production systems that suppress weeds and minimize tillage
Activity B.6: Integrated grain-based cropping systems for biological and economic sustainability

Subproject C: Organic Greenhouse Production

Activity C.1: Crop nutrition for vegetable plant propagation
Activity C.5: Development of an organic greenhouse growing system for tomato that improves energy use efficiency and reuses the crop effluent as nutrient solution
Activity C.6: Development of an organic greenhouse system for intercrop tomato and extended sweet pepper crop grown under supplemental lighting for year-round locally-grown fruit production
Activity C.7: Feasibility of using geothermal energy as heat and humidity control for an organic greenhouse tomato crop
Activity C.8: Optimizing fertilization and irrigation management for a closed greenhouse organic tomato growing system
Activity C.9: Production of organic cuttings and pot plants

Subproject D: Integrated Management of Horticultural Field Crops

Activity D.1: Agroecosystem management for pest control in organic vegetable production
Activity D.2: System productivity and N flows in two organic vegetable long term rotations: high intensity stocked rotation versus a low intensity stockless rotation
Activity D.4: Organic production of vegetable transplants for gardeners
Activity D.5: Organic production of peat blocks for vegetable seedlings and detection of abiotic and biotic stresses
Activity D.7: Development of a weed management system for pumpkins grown for seed in Ontario

Subproject E: Environmental Stewardship and Product Branding

Activity E.1: Modeling farm scale energy and nutrient efficiency, and Global Warming Potential, as affected by management
Activity E.2: Modeling Global Warming Potential (GWP) reductions associated with sub-watershed wide transition to organic farming

Subproject F: High Value Fruit Production

Activity F.1: Organic management of black currant during early establishment and production for an export market
Activity F.2: Weed management for organic wild blueberry production
Activity F.3: Ecologically sound soil management in perennial fruit plantings
Activity F.4: Innovative herbicide and fungicide replacement strategies for organic apple production
Activity F.6: Organic production of strawberries and raspberries under tunnels
Activity F.7: Control of Rosy Apple Aphid (RAA) in organic apple orchards

Subproject G: Benchmarking the Organic Dairy Production System

Activity G.1: Assessment of health, welfare and milk composition on organic and conventional dairy farms

Subproject H: Organic Food Processing

Activity H.4: Assessment Alternative approaches to direct addition of nitrite/nitrate for organic cured meats

Subproject I: Sheep Parasite Control

Activity I.1: Over-wintering of gastrointestinal parasites in organic sheep production

Conference Program

Monday, February 20		
7:00 pm	**Welcome Reception** Join us at the Canad Inns Destination Centre Fort Garry for an opening reception. Feast on tasty organic delights with locally supplied organic food from Fresh Option, and mingle with others involved in organic research in Canada and from abroad. The registration desk and presentation upload station will also be open, beginning at 6:00 pm.	
Tuesday, February 21		
7:45 am	Buses leave Canad Inns for University of Manitoba. The last bus will depart at 8:00 am.	
8:00 am	Registration opens in the ***Atrium*** of the University of Manitoba, Agriculture Building (#38) Poster set up in Rooms ***134 & 138***. Presentation upload station will also be open.	
	Richardson International Auditorium. *Chair Andy Hammermeister, OACC*	
8:30 am	Opening remarks from Dr. Andy Hammermeister (OACC), Dr. Martin Entz (University of Manitoba) and Ted Zettel (Organic Federation of Canada and Organic Meadow)	
8:40 am	Organic Research in Canada: Still Small but Roaring *Invited speaker: Dr. Ralph C. Martin of the University of Guelph*	
9:00 am	Is Organic Agriculture Fit for the Challenges of the Future? *Keynote addresses by Dr. Urs Niggli of FiBL Switzerland*	
10:00 am	Refreshment Break in the ***Atrium*** and Poster Set-up in ***Rooms 134 & 138***	
	Soil Fertility, Quality and Health ***Richardson International Auditorium*** *Chair: Eric Bremer, Western Ag Innovations*	**Livestock Productivity, Health and Welfare** ***Carolyn Sifton Lecture Theatre*** *Chair: Ted Zettel, OFC and Organic Meadow*
10:30 am	Drivers of Arbuscular Mycorrhizal Fungi Communities in Canadian Wheat Fields *Chantal Hamel,* *Agriculture and Agri-Food Canada (AAFC)*	Dairy Cow-Based Measures of Welfare on Organic and Conventional Dairy Farms in Southern Ontario *Anita Tucker, University of Guelph*
10:45 am	Soil Phosphorus Pools and Sorption Capacity in Long-term Organic and Conventional Management Systems *Tandra Fraser, University of Guelph*	Organic Dairy Case Study: Strategies for Somatic Cell Count Management from 38 Quebec Dairy Farms *François Labelle, Valacta*
11:00 am	Is Plant-Available Phosphorus Limiting in Organic Farm Soils? What We Know and Where to Go *Kim Schneider, University of Guelph*	Pathogen Identification and Incidence Rates of Mastitis on Organic and Conventional Dairy Farms in Southern Ontario *Léna Levison, University of Guelph*
11:15 am	Comparison and Screening of Phosphate Solubilizing Microorganisms for Plant Growth Promotion of Apple Seedlings *Molly Thurston,* *University of British Columbia*	Risk for Johne's Disease in Organic and Conventional Dairy Herds in Ontario *Laura Pieper, University of Guelph*
11:30 am	Soil Health After 19 Years Under Organic and Conventional Agriculture Management *Sarah Braman,* *University of Manitoba*	Effect of Mannan-Oligosaccharides on Innate Immune Response of Broiler Chickens Fed Organic Diet and Challenged with *Clostridium perfringens* *Juan C. Rodriguez-Lecompte,* *University of Manitoba*
11:45 am	Crop Nitrogen Status and N Use of Potato Cultivars in Organic Farming under Cool Temperate Climate Conditions *Thorsten Haase, University of Kassel*	Exploring the Unique Role of Hairy Vetch in Grazed Green Manure Systems *Joanne Thiessen Martens, University of Manitoba*

Tuesday, February 21 (Continued)		
12:00 pm	Lunch (provided) in the ***Atrium***	
	Food, Sustainability and Organic Systems ***Richardson International Auditorium*** *Chair: Ralph C. Martin, University of Guelph*	**Greenhouse Production** ***Carolyn Sifton Lecture Theatre*** *Chair: Paula Halabicki, MAFRI*
1:15 pm	Biodiversity as Affected by Farming Systems and Landscape: A Study of Different Trophic Levels *Invited Speaker Céline Boutin, Environment Canada*	Organic Greenhouse Cluster Research Activities: An Overview *Martine Dorais, AAFC and Université Laval*
1:45 pm		Comparison of Two Cooling and Dehumidifying Methods for a Semi-Closed Organic Tomato Greenhouse *Marise Vallières, Université Laval*
2:00 pm	Productivity and Environmental Benefits of Organic Farming Systems - Balancing the Tradeoffs *Invited Speaker Derek Lynch, Nova Scotia Agricultural College*	Optimizing Fertilisation for Organic Tomatoes and Peppers Grown in High Tunnels *Jean Duval, CETAB+*
2:15 pm		Organic Greenhouse Tomato Production in a Closed System *Valérie Gravel, AAFC and Université Laval*
2:30 pm	Tools for Geospatial and Agent Based Modelling to Evaluate Climate Change in an Agricultural Watershed in Transition to Organic Agriculture *Alireza Ghaffari, York University*	Postharvest Infection of Organically Grown Greenhouse Tomatoes Caused by a Range of Fungi in British Columbia *Andrew Wylie, Simon Fraser University*
2:45 pm	The Economics of Various Organic Potato Rotations in Atlantic Canada *Mohammad Khakbazan, AAFC*	Remote Sensing of Nitrogen and Water Status on Boston Lettuce Transplants in a Greenhouse Environment *Nicolas Tremblay, AAFC*
3:00 pm	Investigating Soil NO_3^- and Plant N Uptake when Green Manures are Grazed *Harun Cicek, University of Manitoba*	Biochar Used in Combination with Organic Fertilization for Potted Plants: Its Effect on Growth and *Pythium* Colonization *Valérie Gravel, AAFC and Université Laval*
3:15 pm	Relationships between Forage Productivity, Quality, Legume Fixed Nitrogen and Soil Phosphorus Fertility on Organic Dairy Farms *Mike Main, Nova Scotia Agricultural College*	Ornamental Potted Plants: Production under Organic Fertilization *Valérie Gravel, AAFC and Université Laval*
3:30 pm	Refreshment Break in the ***Atrium*** and Poster Viewing in ***Rooms 134 & 138***	
4:15 pm	***Richardson International Auditorium.*** *Chair: Caroline Halde, University of Manitoba* The Long-Term Agroecological Research (LTAR) Experiment in Iowa: Benefits of Longer Organic Crop Rotations in Terms of Crop Production, Soil Quality and Economic Performance *Plenary address by Dr. Kathleen Delate of Iowa State University*	
5:00 pm	Buses depart the University of Manitoba and return to Canad Inns	
6:30 pm	Organic Banquet: ***Canad Inns Destination Centre Fort Garry Hotel*** Mingle with a drink and then sit down to tantalize your taste buds and mind with a delicious organic banquet, with locally supplied organic food from Fresh Option, and guest speaker Laura Rance at the Canad Inns Destination Centre Fort Garry. The cash bar will open at 6:30 pm, and the banquet will begin at 7:00 pm.	

Wednesday, February 22		
7:45 am	Buses leave Canad Inns for University of Manitoba. The last bus will depart Canad Inns at 8:00 am.	
	Richardson International Auditorium. *Chair: Andy Hammermeister, OACC*	
8:30 am	State of the Industry – Trends, Challenges and Opportunities *Keynote address by Gunta Vitins of Vitins Consulting*	
9:15 am	Many Little Hammers: An Ecological Approach to Weed Management *Plenary address by Dr. Eric Gallandt of the University of Maine*	
10:00 am	Refreshment Break in the ***Atrium*** and Poster Viewing in ***Rooms 134 & 138***	
	Cereal-Based Cropping Systems ***Richardson International Auditorium*** *Chair: Anne Kirk,* *Western Applied Research Corporation*	**Fruit & Vegetable Field Crops** ***Carolyn Sifton Lecture Theatre*** *Chair: Jean Duval, CETAB+*
10:30 am	Multi-criteria Analysis of the Glenlea Organic Rotation: The First 19 Years *Martin Entz,* *University of Manitoba*	High tunnel Production of Organic Strawberry: Effects of Fertilization Management on Three Cultivars *Linda Gaudreau, Université Laval*
10:45 am	Wheat Cultivar Development: Selection for Adaptation to Organic Production Systems *Stephen Fox, AAFC*	Fertility Management of Establishing Organic Blackcurrants (*Ribes nigrum* L.) *David Hobson,* *Nova Scotia Agricultural College*
11:00 am	Participatory Wheat Breading on the Prairies *Iris Vaisman,* *University of Manitoba*	Health Benefit and Horticultural Potential of Wild Blueberry Ecotypes of Northwestern Ontario *Azim Mallik, Lakehead University*
11:15 am	Using Mulches to Reduce Tillage in Organic Grain Production in Western Canada *Caroline Halde,* *University of Manitoba*	Management Strategies for Control of the Rosy Apple Aphid, *Dysaphis plantaginaea* (Passerini) (Homoptera: Aphididae) in Organic Apple Orchards in British Columbia *Tamara Richardson,* *University of Northern British Columbia*
11:30 am	Integration of Cultural and Mechanical Weed Control Strategies Enhance Weed Control in Organic Cropping Systems *Dilshan Benaragama,* *University of Saskatchewan*	Assessment of Carrot (*Daucus carota*) and Leek (*Allium porrum*) as Companion Organic Crops: Can they Benefit Each Other? *Maxime Lefebvre, IRDA*
11:45 am	Potential of Various Amendments and Management Practices in Preventing Nutrient Deficiencies and Improving Yields for Sustainable Organic Crop Production *Sukhdev Singh Malhi, AAFC*	Organic and Integrated Approaches to European Wireworm Control in Atlantic Canada *Karen Nelson,* *Nova Scotia Agricultural College*
12:00 pm	Nitrogen Dynamics of Various Organic Amendments on Cereal Crop Production within Organic Systems in Southern Ontario *Alex Woodley, University of Guelph*	Canada's Organic Science Cluster, Activity D.1: Agroecosystem Management for Pest Control in Organic Vegetable Production *Maryse Leblanc, IRDA*
12:15 pm	Lunch (provided) in the ***Atrium***	

Wednesday, February 22 (Continued)		
	Extension of Organic Research ***Richardson International Auditorium*** *Chair: Laura Telford, MAFRI*	**Social Science and Organic Agriculture** ***Carolyn Sifton Lecture Theatre*** *Chair: Margaret Savard, OACC*
1:30 pm	Canadian Organic Extension Network *Keri Sharpe,* *Alberta Agriculture and Rural Development*	Innovation Shared is Resilience Built: Farmer-to-Farmer Learning and Adaptation To Climate Change *Hannah Roessler, University of Victoria*
1:50 pm		Participatory Approaches to Organic Certification – Experiences from Mexico *Erin Nelson, University of Guelph*
2:00 pm	The Direction of Extension in the USA *Invited Speaker Dr. Frank Kutka,* *North Dakota State University*	
2:10 pm		Globalizing Organics: Trade Regulations and the Changing Meaning of Organic *Lisa Clark, University of Saskatchewan*
2:30 pm		Buying Local Organic Food: A Pathway to Transformative Learning *A. John Sinclair, University of Manitoba*
3:00 pm	Refreshment Break in the ***Atrium*** and Poster Viewing in ***Rooms 134 & 138***	
3:30 pm	***Richardson International Auditorium.*** *Moderated by Laura Telford, MAFRI* Plenary Panel: Fostering farmer-researcher collaboration With Martin Entz, Joanne Theissen Martens, Iris Vaisman and Harun Cicek, University of Manitoba; Dan and Fran DeRuyck, Top of the Hill Farm; Marvin J. Dyck, Kroeker Farms.	
5:00 pm	Buses return to Canad Inns	
	Supper (on own)	

Thursday, February 23 : Organic Science Cluster Strategic Meetings	
8:30 am to 3:30 pm	The Science Cluster model is increasingly being used by AAFC for funding agricultural research of relevance to Canadians. The current Organic Science Cluster ends in March 2013. This full day of Organic Science Cluster Strategic Meetings will be used to discuss the priorities for research and formulate a strategic plan as we prepare the application for the next Organic Science Cluster for the period of April 2013 to March 2018.
	Richardson International Auditorium
8:30 am	Opening remarks by Andy Hammermeister, OACC: Purpose & Overview of Science Cluster Initiative
8:45 am	AAFC Growing Forward 2 Presentation
9:05 am	International Panel with Derek Lynch, Urs Niggli, Linda Edwards, Martin Entz and Eric Gallandt *Chair: Stephen Fox, AAFC*
10:30 am	Breakout sessions - What should the priorities be for Canadian Organic Research? *Facilitated by Don Flaten, University of Manitoba*
12:00 pm	Lunch (provided) in the ***Atrium***
1:00 pm	Breakout session continued
2:00 pm	Strategic directions & priorities
3:25 pm	Closing remarks by Andy Hammermeister, OACC
3:30 pm	Adjourn

Poster Presentations

Soil Fertility, Quality and Health

S1. Advances in the Characterization of Soil and Root Arbuscular Mycorrhizal Communities and their Role in Sustainable Agriculture
Cristina Micali, Université de Montréal

S2. Can Fungi replace Fertilizers? The Potential of Mycorrhizal Fungi in Organic Agriculture
Roland Treu, Athabasca University

S3. Development of a System for Monitoring of Gaseous Losses During Composting of Solids from Hog Slurry
Jolene Rutter, University of Manitoba

S4. Differential Response of Soybean (*Glycine max* L.), Canola (*Brassica napus* L.) and Spelt (*Triticum spelta*) to Organic Amendments
Roger Nkoa, University of Guelph

S5. Diversity of Arbuscular Mycorrhizal Fungi in Cultivated Soils of the Canadian Prairie
Chantal Hamel, AAFC

S6. Phosphorus Availability in Organic Dairy Farm Soils: A Closer Look at the Role of Soil Biology
Kim Schneider, University of Guelph

S7. Relative Effectiveness of Organic and Inorganic Nutrient Sources in Improving Yield, Quality and Nutrient Uptake of Canola
Sukhdev Singh Malhi, AAFC

S8. Relative Effectiveness of Various Amendments in Improving Yield and Nutrient Uptake under Certified Organic Crop Production
Sukhdev Singh Malhi, AAFC

S9. Synchronizing N Supply with Crop Uptake in Spring Wheat Crop Rotations by Altering Green Manure Management Strategies
Brian Wallace, Nova Scotia Agricultural College and University of Saskatchewan

Livestock Productivity, Health and Welfare

L1. Relationship between Urea in Milk and Ammonia Emissions: An Overview
Meriem Benlamri, Lakehead University

Food, Sustainability and Organic Systems

F1. The Effects of Crimper-Rolled Winter Rye on the Agroecosystem and its Impact on Transplanted Vegetable Crop Productivity
Cinthya Leyva Mancilla, McGill University

F2. Impacts of Wheat Stubble Height on Soil Moisture Levels in Different Canola Growing Climate Regions
Mike Cardillo, University of Manitoba

F3. Including Perennials in Rotation with Annuals Reduces Emissions of Greenhouse Gases from Soil
Tek Sapkota, University of Manitoba

F4. Mycorrhizal-mediated Nitrogen Transfer in a Mixed Legume-Grass Forage Cropping System
Andrew Marshall, University of Guelph

F5. Organic Fertilization Strategies for Hoophouse Production of Tomatoes (*Solanum lycopersicon* L.) in South Coastal British Columbia
Greg Rekken, University of British Columbia

F6. Organic Management that Promotes Luxurious Vegetative Growth Lowers Edamame Yield
Krishna P. Sharma, The Sharing Farm

F7. Perennial Grain Crops and Polyculture: An Ambitious Goal for Organic Agriculture
Doug Cattani, University of Manitoba

F8. Performance Variation of Bush Bean under Different Organic Management Practices
Krishna P. Sharma, The Sharing Farm

F9. Platform for Innovation in Organic Agriculture: A New Concept in Canada
Maryse Leblanc, IRDA

Greenhouse Production

G1. Composts and Forestry Industry Waste as Peat Moss Substitutes in Greenhouse Growth Media
Derek Lynch, Nova Scotia Agricultural College

G2. Enrichment of Artificial Wetlands with Biochar to Improve their Efficiency and Reduce N_2O Emission
Maggie Bolduc, AAFC and Université Laval

G3. Environmental Assessment of an Organic Integrated Greenhouse Tomato Crop Grown Under Northern Conditions Compared to a Conventional Crop
Martine Dorais, AAFC and Université Laval

G4. Organic Fertilization and its Effect on Development of Sweet Pepper Transplants
Valérie Gravel, AAFC and Université Laval

G5. Organic Production of Vegetable and Herb Transplants
Valérie Gravel, AAFC and Université Laval

G6. Organically-grown Greenhouse Tomato Under Supplemental Lighting
Martine Dorais, AAFC and Université Laval

G7. A Passive Biological Approach to Remove Plant Pathogens from an Organic Greenhouse Effluent
Martine Dorais, AAFC and Université Laval

G8. Soil Oxygen Enrichment in Organically-grown Greenhouse Tomato
Valérie Gravel, AAFC and Université Laval

G9. Soil Salinization of Organically-grown Greenhouse Tomato
Valérie Gravel, AAFC and Université Laval

G10. The Use of Passive Bioreactors to Simultaneously Remove NO_3, SO_4 and Plant Pathogens from Organic Greenhouse Effluent
Martine Dorais, AAFC and Université Laval

Cereal-Based Cropping Systems

C1. Cereal Cover Crops for Early Season Weed Control in Organic Field Beans
Rachel Evans, University of Manitoba

C2. Comparing Reduced Tillage Implements for Termination of Cover Crops
Kristen Podolsky, University of Manitoba

C3. Facilitating Organic Soybean Cultivation under Cool Temperate Climate Conditions
Thorsten Haase, University of Kassel

C4. Grain Yield, Yield Structure and Quality of Organic Winter Wheat as Affected by Row Width and Seeding Density
Thorsten Haase, University of Kassel

C5. Intercropping Barley and Pea for Agronomic and Economic Considerations
Sukhdev Singh Malhi, AAFC

C6. Intercropping Canola and Pea for Agronomic and Economic Considerations
Sukhdev Singh Malhi, AAFC

C7. Reduced Tillage and its Impact on Canada Thistle (*Cirsium arvense*) and Grain Yield in a Cereal-Based Stockless Organic Crop Rotation
Thorsten Haase, University of Kassel

C8. Winter-hardy Grain Legumes: Suitability of Winter Pea (*Pisum sativum* L.) Genotypes for Cropping with Different Mixture Partners
Thorsten Haase, University of Kassel

Fruit and Vegetable Field Crops

H1. Characterization of Berry Quality of *Ribes nigrum* in Relation to Harvest Timing and Cultivar
Nicholas Taylor, Nova Scotia Agricultural College

H2. High Tunnel Production of Organic Raspberries
Linda Gaudreau, Université Laval

H3. One Step Towards Organic Seed Pumpkin Production in Québec: Evaluation of Three Varieties: ‘Kakai’, ‘Snackjack’ and ‘Styriaca’
Josée Boisclair, IRDA

H4. Orchard Floor Management Affecting the Performance of Young Organic ‘Honeycrisp’ Apple Trees
Julia Reekie, AAFC

H5. Preliminary Observations on the Potential of Flowering Strips to Attract Beneficial Insects
Josée Boisclair, IRDA

H6. Weed Master: A Scale-appropriate Weeding Tools for Small Vegetable Farms
Maryse Leblanc, IRDA

Extension

E1. Bringing Science Home to the Farm: Bridging the Gap Between Producers and Researchers

Allison Squires, Upland Organics

E2. An Organic Inspector's Dilemma: Responding to Questions on Production Standards Requirements and Sharing Relevant Research While Avoiding Consulting with Organic Operators

Janine Gibson, Organic Food Council of Manitoba

E3. Using a 12 Acre Organic "Mini-farm" for Extension and Education

Martin Entz, University of Manitoba

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Keynote, Plenary and Invited Presentations

Organic Research in Canada: Still Small but Roaring

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Background:
Research in organic agriculture is relatively recent in Canada. Organic farmers and other organic practitioners conducted some of their own experiments while applying what they knew from previous generations, other pioneers and research relevant to organic systems. Within the last three decades, direct research for organic agriculture has increased. The results are of benefit to certified organic practitioners and those in conventional agriculture who want to improve profits, conserve energy, develop resilience to climate change and other variability and maintain healthy soil, clean air, clean water and biodiversity.

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Overview:
As agricultural science developed in Canada and elsewhere in the last century, synthetic chemical inputs and other interventions to improve productivity were increasingly common. There was a shift from relying on nutrient and energy flows within farms to using a complex array of yield enhancing products from off-farm. By the last part of the 20^{th} century it was apparent that 'organic-by-default' was not sufficient to differentiate traditional organic agriculture from input-intensive agriculture.

However, some inputs such as fossil fuels, machinery and associated technology were deemed to be appropriate. In line with other countries, Canadian organic certifying bodies developed to not only categorize permitted and restricted substances, but to also design practices based on ecological principles. Organic certification is based on inspecting processes rather than on threshold levels of specific substances. Initially this was a challenge to agricultural researchers.

It is only within the last two decades that organically certified land and livestock has been used for research in organic agriculture. Farmers correctly noted that researchers should also be subject to short and long term organic conditions. After all, the noun 'organic' identifies the sector based on the fundamental principle of feeding the soil to enrich organic matter. Research based only on short term organic management may be applicable to organic farmers although it is necessary to distinguish such research from that on certified organic research units.

Since 2001, OACC has coordinated organic research across Canada and the Organic Science Cluster, approved in 2009, was a major step forward.

Conclusions:
Organic agriculture is unique in that it is clearly defined along a complete value chain and serves as an excellent model of sustaining food systems. Regardless of the proportion of Canadian practitioners who adopt organic certification, the impact of research and practice in organic systems provides significant options and a value-chain benchmark as all agricultural researchers and practitioners continue efforts to sustain adequate food production and resilience.

Acknowledgments: Thank you to all industry sponsors acknowledged on the OACC website (www.oacc.info), now and in past annual reports, who have stepped up to provide funds to enable scientists developing organic research programs.

Is Organic Agriculture Fit for the Challenges of the Future?

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Conventional agriculture "simply is not the best choice anymore today" the UN Special Rapporteur on the right to food Olivier De Schutter stressed. "A large segment of the scientific community now acknowledges the positive impacts of agro-ecology on food production, poverty alleviation and climate change mitigation – and this is what is needed in a world of limited resources[1]." Organic agriculture is such an agro-ecology-based farming method. It is globally still a niche, using 0.9% of farm land (Canada 1%!). Nonetheless, in some countries, it has reached relevant proportions: 20% in Austria or 12% in Switzerland. Currently, the transition rate is 8% among European farmers, negative in China and India and stagnant in the rest of the world[2]. A vivid demand characterizes the food markets which have grown from 40 to 44 billion € in 2010 (59 billion US$) and which are expected to grow further at the same rate.

Nonetheless, even with an optimistic interpretation of these figures, it is obvious that organic farming can neither play a significant role in overcoming the global challenges of our food systems nor be a realistic option for the majority of farmers. This is regrettable as organic farming is a good combination between productivity, farm profitability and delivering environmental (and other public) goods and services. There is abundant evidence that organic farms –compared to conventional ones - show higher organic matter contents, higher biomass, higher enzyme activities of microorganisms, better aggregate stability, improved water infiltration and retention capacities, and less water and wind erosion[3]. A further increase of carbon capture in organically managed fields can be measured when reducing the frequency of soil tillage in organic crop rotations[4]. The capacity of farms to adapt to climate change also depends on the diversity of species and the diversification of farm activities. In addition, landscapes rich in natural elements and habitats buffer climate instability effectively. It is proven in hundreds of studies that organic agriculture is a good strategy for halting biodiversity loss and diversifying landscape quality[5].

The advantages of organic agriculture clearly show the essentiality of sufficient capacities for applied research, dissemination and training. Farmers only become interested in organic agriculture if it offers good solutions and if they perceive it as being innovative. Even in Switzerland, where the demand for organic produce exceeds by far the national supply and where subsidies make organic farming profitable, it is difficult to increase the number of producers beyond 12 %.

A huge potential for innovation is still buried in the system approach of organic farming, and even more potential lies in the combination of organic farming and smart technologies and solutions. In my speech I will give examples of scientific work and will also discuss implications on and potential conflicts with organic standards. Science will become more important in the coming decades and the participation of farmers will be important in order to stimulate their interest.

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[1] The report "Agro-ecology and the right to food" is available at http://www2.ohchr.org/english/issues/food/docs/A-HRC-16-49.pdf

[2] Willer, H., Lernoud, J. and Kilcher, L. (eds.) (2012) The world of Organic Agriculture. Statistics and emerging trends 2012. Report published by IFOAM and FiBL.

[3] Niggli, U. (2010) Organic agriculture: a productive means of low-carbon and high biodiversity food production. Trade and Environment Review 2009/2010: 112-142, UNCTAD.

[4] Berner, A., Hildermann, I., Fließbach, A., Pfiffner, L., Niggli, U., Mäder, P. 2008. Crop yield and soil fertility response to reduced tillage under organic management, Soil & Tillage Research, 101: 89-96.

[5] Hole, D.G., A.J. Perkins, J.D. Wilson, I.H. Alexander, P.V. Grice and A.D. Evans (2005): Does organic farming benefit biodiversity? *Biological Conservation*, 122, 113-130.

Biodiversity as Affected by Farming Systems and Landscape: A Study of Different Trophic Levels.

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Background:
Agricultural areas occupy large proportions of the land in many countries and over 50% of areas worldwide. Although in Canada less than 10% of the land is devoted to agriculture, it is concentrated in areas with unique flora and fauna, e.g. the Prairies and the Great-Lakes/St-Lawrence corridor. Since the 1970s there has been an increased intensification of agriculture with focuses on high crop yields and concomitant use of agrochemicals. As such, herbicides and fertilizers are sprayed on over 25 mi ha of land annually. Maintenance of biodiversity within agricultural areas should be a primary role of the main users of the land. Furthermore, biodiversity provides benefits to agriculture since it is itself reliant on biodiversity providing multiple ecosystem services including pollination of crops, soil formation, nutrient cycling, maintenance of hydrological cycles, etc. These processes and functions are all driven by interactions between components of biodiversity. Organic farming has emerged as one of the solutions to enhance agricultural sustainability. Environmental concerns and food safety have both contributed to the growth of organic farming practices in Canada. In addition, biodiversity loss is also of concern although only limited studies in Canada have been conducted to assess differences in biodiversity between organic and conventional farming.

Project Overview:
The current study was conducted between 1998 and 2002 in Peterborough, Ontario. The primary objective was to study biodiversity in organic and conventional farming. We chose to assess biodiversity in woody hedgerows and their adjacent crop fields (soybean and cereal crops) in each farming type. We selected woody hedgerows because they are common and often represented the only non-crop habitat remaining within farming landscapes and they are essential links that ensure connectivity between semi-natural habitats and thus constitute an integral part of agrarian systems. Finally, we measured the influence of other habitat types (woodlots, old fields, ditches, fencerows, road sides and small wetlands) in the Peterborough landscape on biodiversity. Several groups of organisms from different trophic levels were inventoried. A total of 193 plant species from 58 families, 30,807 arthropods (mostly insects) from 117 families, an additional 26,020 moths from 408 species and 12 families, 7,966 earthworms from 7 species and 5,247 birds from 90 species (fall + spring) were found during our study. In general, organic sites sheltered a higher number of organisms (plants, moths, earthworms and birds) and in greater abundances than conventional sites. Species composition also differed between organic and conventional farms. Biodiversity was always strongly significantly different between hedgerows and fields at all trophic levels.

Conclusions:
In the present study it was found that organic farming is linked to a stronger maintenance of biodiversity in agricultural environments, not only for biodiversity in fields but also in adjacent hedgerows. It was also demonstrated that preservation and protection of habitats such as woody hedgerows is of key importance and may be vital to the formation of a balance between high agricultural yield and protection of wild biodiversity.

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Productivity and Environmental Benefits of Organic Farming Systems – Balancing the Tradeoffs.

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Organic farms and farming systems are generally credited with providing environmental, ecological and social benefits. These include but are not limited to: Maintenance of soil organic matter, soil quality and soil health; reduced off-farm losses of nitrogen and phosphorus; improved on-farm diversity of plants and some wildlife; reduced use of energy by the farm; improved support of pollinating insects and crop pollination; and improved husbandry and welfare of farm animals. However, organic cropping and livestock farms are not homogeneous, and organic standards allow for a spectrum or range in farm management intensity and approach. These differences in management among organic farms can include variation in use of crop rotations and diversity of cropping, differences in intensity of nutrient use, purchased feeds and supplements and in farm livestock density (or livestock stocking rate), differences in pest management approach and creation and management of non-crop habitats on the farm etc., all of which influence both the productivity of the farm and also the environmental impact and ecological services provided by the farm. Drawing upon primarily Canadian studies, the presentation will examine this tradeoff between organic farm productivity and ecological and environmental services to society provided by organic farms, which is a key factor in developing an agroecological approach to organic agriculture in Canada, supported by producers, consumers and society as a whole.

The Long-Term Agroecological Research (LTAR) Experiment in Iowa: Benefits of Longer Organic Crop Rotations in Terms of Crop Production, Soil Quality and Economic Performance.

K. Delate

Professor, Iowa State University, Ames, Iowa; Cynthia Cambardella, Soil Scientist, USDA-ARS National Lab for Ag. and the Environment, Ames; Craig Chase, Farm Management Specialist, Iowa State University, Ames, Iowa

The Iowa State University Neely-Kinyon Farm Long-Term Agroecological Research (LTAR) experiment was established in Greenfield, Iowa, in 1998 to study the long-term effects of organic production in terms of soil health and plant performance. In the first 13 years of the LTAR, yields of organic corn, soybean and oats have been equivalent to or slightly greater than their conventional counterparts. The 12-year average for alfalfa and 8-year average for winter wheat showed no significant difference between organic yields and the Adair County average. The use of organic practices and premium organic prices resulted in returns to land and management of $449 per acre for the organic corn-soybean-oat-alfalfa rotation compared to $262 per acre for the conventional corn-soybean rotation in 2010. Results from the LTAR experiment demonstrated that overall soil quality, and especially soil N mineralization potential, was highest in the 4-year organic crop rotation that includes two years of grass/legume hay. Soils in all organic plots receiving only local, manure-based amendments increased their supply of total nitrogen by 33%, along with higher concentrations of carbon, potassium, phosphorous, magnesium and calcium. Results from the LTAR experiment demonstrate that carbon budgets developed from organic rotations show that the 4-yr organic cropping system can potentially sequester as much soil organic carbon (SOC) (0.53 Mg C ha^{-1} y^{-1}) in the top 15 cm as converting from plowing to no-tillage production. Increases in SOC also enhance soil C and N cycling processes and potentially reduce N loss from the rooting zone, thus mitigating groundwater pollution. Based on our analysis of organic operations across the U.S., it was determined that organic production could sequester 28% more tons CO_2 eq. $acre^{-1}$ yr^{-1} than conventional no-tillage production. Thus, environmental benefits from greenhouse gas reduction could incentivize increased conversion from conventional to organic production across the U.S.

State of the Industry – Trends, Challenges and Opportunities

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Background:
Canada's organic sector has experienced tremendous growth over the past decade and continues to be one of the world's top ten organic markets, but it is struggling with a series of challenges that could undermine the sector and its competitiveness. We will examine a few of these challenges and opportunities for further growth and development.

Overview:
Canada's organic market grew an estimated 30% from 2008, reaching $2.6 billion[1] in retail sales in 2010, representing 2.5% of total food sales in Canada. Certified organic farms represent close to 2% of all farms in Canada, numbering approximately 4,000 with 695,463 hectares[2] under organic production. Internationally, Canadian producers and processors have a strategic advantage, gaining access to 96% of the $55 billion world market through ground-breaking equivalency agreements with the US and EU. Over 35%[3] of US companies operating in the organic market source organic ingredients from Canada. Despite the recession, Canada's organic sector is doing well – or is it?

Demand is increasing, but supply is tightening. Industry stakeholders recently reported that producer numbers could be declining by as much as 30% in certain prairie provinces, due to strong conventional commodity prices that are enticing growers away from organic, and an undermining of the sector by competing natural claims. With tight supply, prices are increasing and Canada is importing products that it once produced in larger volumes. Recognizing that, historically, Canada's organic sector was developed through imports followed by import replacement, this is now a step backwards. In addition, research indicates that over 40%[4] of consumers believe a "natural" claim meets a government-enforced standard, whereas "organic" does not; and they gravitate towards the slightly less expensive natural product, not realizing that in actuality they are purchasing conventional food.

These pressures, coupled with the challenges of non-regulated intra-provincial trade of questionable non-certified organic foods that compete with certified organic products, have destabilized the organic market for Canadian producers and processors. Organizations such as the Canada Organic Trade Association and Agriculture and Agri-Food Canada's Organic Value Chain Roundtable are spearheading development and research initiatives designed to improve Canada's competitiveness, including a sector branding campaign, a risk management plan, research to indentify barriers to retail sales, and a long term international strategy. More work needs to be done to support new entrants, encourage producers to maintain certification, provide knowledge transfer, and encourage conversion.

[1] Canada Organic Trade Association
[2] Canada Organic Growers
[3] Organic Trade Association
[4] Brandspark International, 2010 Consumer Survey

Many Little Hammers: An Ecological Approach to Weed Management.

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University of Maine

"Many Little Hammers" aims to diversify stresses placed on weed populations to include fecundity, post-dispersal seed survival, and seedling establishment, in addition to seedling survival that is the focal point for cultivation. It is a philosophy of weed management that requires and aims to exploit diversity to result in improving weed management over time, considering inherent limitations of physical weed control: Variable efficacy affected by a wide range of operator, weed species and environmental conditions. Diverse rotations, cover crops and green manures add diversity, but their widespread use on organic farms, many that have very high weed populations, demonstrates that they do not necessarily benefit weed management. The impact factor for these practices varies widely based on the associated management. "Critical Weed-free Period Managers" and "Seedbank Managers" both rotate crops and may cover crop, but the former manages weeds with an eye towards early cultivation to give the crop a competitive advantage, while the latter adds to this disturbance events timed carefully to encourage "debiting" of the weed seedbank while preempting seed rain, seedbank "credits." Thus, maximal impact of diversification requires knowledge of the biology of target species.

But, why bother? Cultivation not only works, it is satisfying. And, many successful farmers rely almost exclusively on intensive early cultivation to reduce weed densities to tolerable levels (e.g., Critical Weed-free Period Managers). Cultivation, however, only kills a proportion of the seedlings present, typically somewhere between 50 and 90%. In other words, 50 to 10% survive, which, depending on the initial density, may still be a high density, requiring additional cultivation passes, or costly hand weeding. Thus, one incentive for deploying high impact stresses at multiple points in a weed's life cycle is to reduce the initial density of seedlings that will be subject to cultivation. Further incentive to consider a more knowledge- or management-intensive multiple stress approach to weed management may be embedded in the multiple benefits of diversification; specifically, practices that contribute to improved soil quality. Crop rotation, cover crops, green manures, organic amendments, and mulching can each be implemented in ways that stress, have no effect, or even benefit weeds. Central to the success of these practices is the timing of disturbances based on knowledge of the temporal patterns of weed emergence and reproduction. A final incentive may be increased management options offered by lower weed pressure. Fields with a low seedbank can support any cash or cover crop whereas an abundant seedbank requires a crop that supports intensive cultivation.

Many Little Hammers requires both crop diversity and, knowledge of weed biology for optimal management. It is an approach in which success depends on both initial conditions—i.e., the density of the weed seedbank—and the impact factor of particular management decisions. Simulation models and case studies of successful organic farmers support this conceptual framework, offering evidence that progress in weed management is possible and emphasis on cultivation can be reduced if supported by practices that contribute to a declining weed population.

Canadian Organic Extension Network

K. Sharpe
Organic Business Development Specialist, Alberta

Vision: No Question Goes Unanswered

Mission: To drive continuous improvement and innovation of the Canadian Organic Agriculture and Food Systems through knowledge transfer.

Successes:

Complete to date

-Conducted an environmental scan of organic extension activities across the country.

-Gathered in Banff, August 2010 for an in-person meeting of extension stakeholders including provincial organic specialists, provincial and regional producer groups, and national organic organizations.

-Reached consensus on priorities, vision, mission and direction.

-Developed a national personnel directory - see on-line link below.

-Committed to regular conference calls for members and updates of extension activities across the country.

Continuing

-Developing a strategic plan – on-line when completed. See below for link.

-Developing OACC relationship so resources are available to all.

Challenges

-Accessing funding.

-Maintaining and attracting new personnel.

Key Documents:

http://organicalberta.org/organic-extension
http://www.oacc.info/phpbb3/index.php

Personnel Directory
This is a list of extension personnel in each province. It is updated regularly.

COEN Extension Activity Updates
Extension activities are highlighted for each region.

The Direction of Extension in the USA.

F. Kutka
North Dakota State University

Until the mid-1800s information sharing among farmers in the United States was largely among neighbors, via magazines, and via farming clubs. Land Grant Colleges were created by the Morrill Act in 1862, and expanded to include Historically Black Colleges in 1890, but these were primarily for education of students at the start. President Lincoln also created the Bureau of Agriculture, later the Department of Agriculture when the Hatch Act provided funds for expansion and for research at the land grant colleges starting in 1887. Bulletins for farmers were printed by both Agricultural Experiment Stations and the US Department of Agriculture, but there was no formal mechanism or funding to fast track the latest information to farm families. Individual Agricultural Colleges and USDA employees began their own outreach with much success and they called for increased Federal support.

In 1914 the Smith-Lever Act created and funded the Cooperative Extension Service which was a joint program of USDA, the Land Grant Universities, and State and County governments. Outreach expanded to include county offices across the country providing print materials, local study groups, field events, and more. Management of individual farms, formation of cooperatives, home economics, and 4H were the early major concerns. Later Extension would be organized around Agriculture and Natural Resources, Family and Consumer Science, Nutrition, Community Development, and Leadership and Youth Development. In the late 1980s the Intertribal Agriculture Council lobbied for a program to bring Extension to Indian Reservations which is done via the Federally Recognized Tribes Extension Program. In 1994 Tribal Colleges were added as a third wave of Land Grant Institutions and Extension programs have begun for many of them in the last ten years.

The methods used by Extension educators in the United States over the years have changed relatively little, with a strong focus on local meetings, state meetings, publications, field demonstrations, professional development of educators, and so on. Many people still report a strong interest in interacting with educators directly. In 1988 the Sustainable Agriculture Research and Education program was created in USDA to promote the understanding, practice, and further development of sustainable agriculture. One of its critical missions has been professional development of Extension educators and encouragement of increased interactions of educators, researchers, and farmers.

However, the speed and use of electronic communications has not gone unnoticed. Websites and email were being used, as soon as these were developed, with much expansion in the last ten years. In 2007 a web based outreach platform for 74 University Extension programs called eXtension was launched. It allows constant access to information concerning community, disasters, energy, family, farm, pest management, and youth issues, including options for Twitter and Facebook updates. Later that year a visioning meeting was held to define an eOrganic program and funds were secured via federal grants. eOrganic is also organized into Communities of Practice which come together around critical issues and USDA funded projects related to organic agriculture. These Communities of Practice also develop new online print and video content to be shared through the website. The program has helped to organize dozens of nationwide webinars on organic topics and recorded them for later viewing. Currently it has 186 video clips on its YouTube channel which have received over 640,000 views.

Soil Fertility, Quality and Health

Drivers of Arbuscular Mycorrhizal Fungi Communities in Canadian Wheat Fields.

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* hamelc@agr.gc

Background:
Pathogens have traditionally attracted research attention, but accumulating evidence shows the importance of beneficial microorganisms for sustainable food production. The arbuscular mycorrhizal (AM) fungi form a taxonomic group of soil dwellers secretly promoting the health of most plant species, including wheat. These microscopic fungi naturally mobilize soil minerals for plant uptake and protect roots from pathogen attacks. Despite the important role of AM fungi in plant nutrition, agronomic practices ignore the AM fungal resources naturally occurring in production field soils, as there are currently no practical means to assess the 'health' of a soil`s AM fungal community. We aim to fill this major gap in knowledge by developing indicators of the contribution of the AM fungi to wheat nutrition, in commercial fields. We set out to identify practical indicators of the relative abundance of AM fungi in soils that could reveal where AM fungi are doing a good job with feeding wheat, and where agronomic interventions are required.

Project Overview:
The AM fungal communities living in the soil of 172 wheat fields located across the Canadian landscape was described using cutting-edge metagenomics DNA analysis techniques. They revealed that the vast majority of AM fungi living in Canadian wheat fields belong to unknown species. Podzols seems most favorable to AM fungi as they host 2 to 3 times more AM fungal DNA sequences and 1.5 to 2 times more AM fungal diversity than Prairie soils, among which the Black Chernozems were most populated. AM fungal species distribution across the landscape was best explained by soil fertility. The proliferation of most AM fungi appeared mitigated by high calcium soils. The abundance of soil nitrogen was another key factor of AM fungal species distribution across the landscape. Soil texture and organic matter data derived from the National Soil Databank used Environment Canada weather data and measured soil phosphorus fertility could be used to model the distribution of three of the five major AM fungal strains encountered in the survey. By contrast to expectations, the distribution of AM fungi in the wheat fields surveyed was independent of the identity of the previous crop, and the organic or conventional management used on farms.

Conclusions:
This research demonstrates the possibility of using mathematical models to estimate the quality of important beneficial soil fungal communities invisible to the naked eye. It appears that National data banks on soil and climate and standard soil analytical methods could be used to develop cost effective computerized decision making tools to support an efficient wheat production based on ecological principles.

Acknowledgments: Thank you to Western Ag Innovations, the Canadian Wheat Board, Growing Forward, and Agriculture and Agri-Food Canada.

Soil Phosphorus Pools and Sorption Capacity in Long-term Organic and Conventional Management Systems.

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Background: Widespread phosphorus shortages have been reported in organically managed soils across Canada, although yields often do not reflect deficiencies. Considering that more than 80% of soil P may be unavailable for plant uptake, the current soil test phosphorus may be inaccurately assessing available P in organic systems.

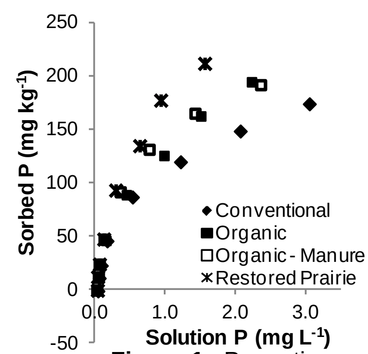

Figure 1. P sorption

Project Overview: The objective of the current study is to examine differences in soil P pools and P sorption capacity in a long-term forage-grain rotation (flax-alfalfa-alfalfa-wheat) and compare between organic, manure-amended (once only) organic, conventional and restored native prairie management. In May 2011, soil samples (0-15 cm; n=20) were collected from the wheat phase of the Glenlea Long Term Crop Rotation and Management research plots at Glenlea, MB. After 20 years the P sorption, or retention, ability of the soil under organic management is higher than conventional but less than the prairie (Figure 1), although these differences were not significant ($p<0.05$). Sequential Hedley P fractionation revealed significantly lower concentrations of both labile and moderately labile P fractions in the organic treatments compared to the prairie and often conventional systems (Figure 2). This was especially true for inorganic (Pi) compared to organic (Po) fractions. These fractions have been operationally defined with decreasing availability for plant uptake as: (1) Resin P-Pi, exchangeable with solution; (2) 0.5 M $NaHCO_3$ P_i and P_o, sorbed on soil minerals and some microbial P; (3) 0.1 M NaOH-P_i, P_o, associated with Fe and Al oxyhydroxides; (4) 0.1 M NaOH after ultrasonification-P_i, P_o, removing P at internal surfaces of aggregates; (5) 1 M HCl-Pi apatite mineral and some occluded P.

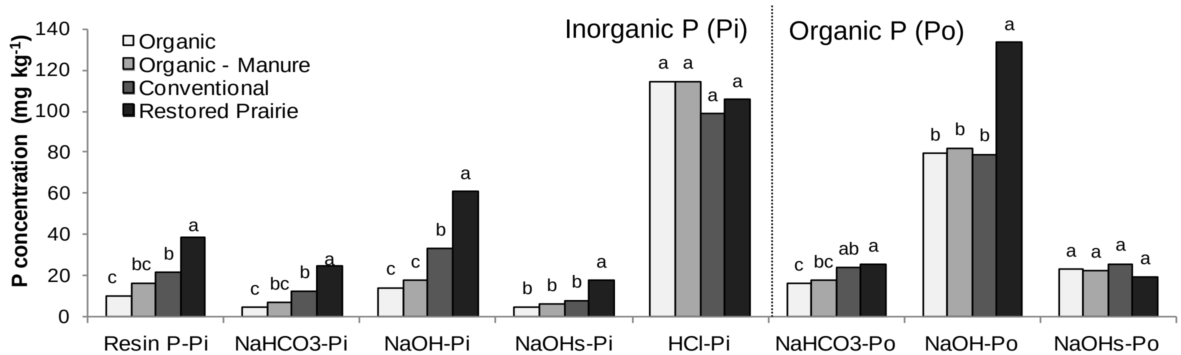

Figure 2. Phosphorus concentration from sequential extraction. Values are treatment means (n=3) with same letters within fractions representing no significant difference at $p<0.05$ as determined by Tukey's test.

Conclusion: Replacement of P in long-term organic systems is essential for maintaining yields, considering both labile and moderately labile P pools may be depleted, especially where hay is removed as in this rotation sequence. The one time manure application does not appear to have achieved this and a second application was added in autumn 2011.

***Acknowledgments**:* Canadian Agri-Science Clusters Initiative, Growing Forward of Agriculture and Agri-Food Canada, and the Canada Research Chairs Program.

Is Plant-Available Phosphorus Limiting in Organic Farm Soils? What we Know and Where to Go.

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Background:
Recent studies exploring soil fertility on Canadian organic dairy and grain farms have reported low levels of Olsen soil test phosphorus, which is an index of plant-available phosphorus. These results may have implications for overall crop productivity, as phosphorus deficiencies reduce yields and may negatively affect the ability of legumes to biologically fix nitrogen from the air. However, despite having low soil test phosphorus, some organic farmers state that their crop yields are acceptable and they do not believe their crops are suffering from a phosphorus deficiency. It has been suggested that increased soil biological activity in organically-managed systems is involved in providing the crop with phosphorus not measured by the conventional soil phosphorus test.

Project Overview:
Based on both existing data as well as recent results obtained from a dairy farm case study, this presentation will outline what is known about assessing soil phosphorus availability on organic farms. The question to be raised is whether the standard soil test used for measuring plant-available phosphorus provides sufficient information for organic farming systems. The data presented will provide insight into additional factors including total phosphorus, total organic phosphorus, arbuscular mycorrhizal root colonization, and the field or farm phosphorus budget, that may also be considered when assessing soil phosphorus fertility.

Conclusions:
The Olsen soil test for soil phosphorus availability, which corresponds with government guidelines for nutrient addition, may not be accurate in predicting plant-available phosphorus in organic forage fields. Additional soil and plant measurements can assist in providing a better assessment of a soils phosphorus supplying capacity. There is a need to develop a practical test/suite of tests that can be performed routinely to provide a better assessment of plant-phosphorus availability in organic fields.

Acknowledgments: The authors would like to acknowledge and thank the following organizations for their financial and/or in-kind support that helped make this research possible: NSERC, OMAFRA, Organic Meadow, the Canada Research Chairs program, and the Swiss Federal Institute of Technology (ETH Zurich).

Comparison and Screening of Phosphate Solubilizing Microorganisms for Plant Growth Promotion of Apple Seedlings.

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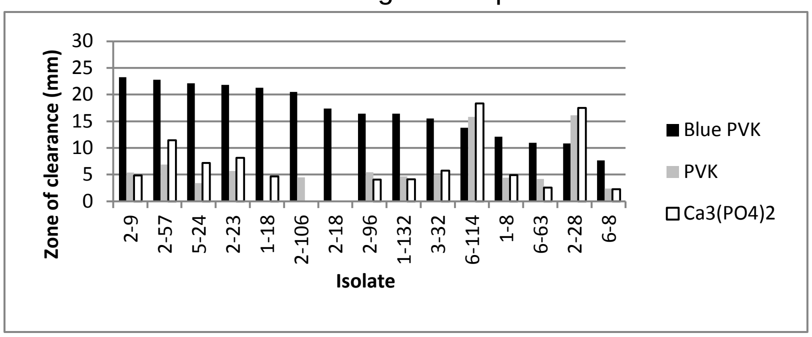
Background:
Replant disorder has been identified as a condition affecting orchards worldwide and organic management strategies are needed. Improved phosphorous (P) nutrition to increase root growth and seedling establishment is one such strategy. P effects on root stimulation and fruit precocity in apple production have been well established; however, few P options exist for Canadian organic growers. The most common P inputs are highly insoluble Rock Phosphate (RP) and Bone Meal. Alternative soluble P sources for organic production are limited; therefore methods of increasing P solubility in the soil are needed.

Project Overview:
In our study, isolates of 101 bacterial isolates collected from the roots of pea, lentil and chickpea crops grown in Saskatchewan soils were screened for P solubilization properties on an insoluble calcium phosphate medium. P solubilization was detected in 34 isolates by measuring the zone of clearance produced by the solubilization of insoluble phosphate.

The twelve best isolates were tested on three solid media: Calcium phosphate medium, Pikovskaya medium (PVK) and on modified PVK containing bromophenol blue. While all isolates solubilized P on all media, the amount of P solubilized by individual strains varied between media. Of the fifteen isolates tested, ten (67%) were *Pseudomonas* spp., three (20%) were *Rhanella* spp., one was *Serratia* sp. and one was *Klebseilla* sp.



The isolates were grown in liquid culture, where a marked decrease in the pH of the solution was observed. Six isolates identified from these *in vitro* studies were inoculated onto apple seedlings grown in growth pouches containing 0.1 g of RP for four weeks and compared to non-inoculated seedlings in the presence of K_2HPO_4, a soluble P source.

Conclusions:
Significant treatment effects were observed in total root length, surface area and the number of root tips produced by seedlings in growth pouch assays. Phosphate solubilization by specific plant growth promoting rhizobacteria may enhance P uptake in young apple trees and may provide an opportunity for organic tree fruit growers to improve seedling performance in the home nursery and in replanted orchard blocks.

Acknowledgments: Thank you to the Province of British Columbia - Ministry of Advanced Education, the Canadian Organic Science Cluster and Novozymes Canada for financial assistance with this project.

Soil Health after 19 Years Under Organic and Conventional Agriculture Management.

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Background:

The number of certified organic acres in Canada increased from 2008 to 2009 reaching 1,718,468 acres[†]. Organic and conventional agriculture systems differ in approaches to managing crop rotation, soil fertility, and pests, which have direct consequences on soil health. The Glenlea long-term rotation located in Manitoba was established in 1992 to compare organic, conventional, no-input and restored prairie grass land management practices. Two 4-yr rotations exist under all agriculture management practices: Annual-grain and grain-forage.

Project Overview:

The objective of the present study was to evaluate the effect of conventional, organic, and no-input agricultural management on soil health. Microbial biomass carbon, microbial metabolic quotient (qCO_2), and microbial biomass phosphorus were measured to evaluate soil health. Microbial metabolic activity in soil characterizes long-term effects of agricultural management on carbon cycling, nutrient sustainability and mineralization-immobilization-turnover. High microbial biomass carbon, high microbial biomass phosphorus, and low qCO_2 reflect a healthy soil. Values for qCO_2 < 0.5- µg/g are considered dormant microbial populations.

Microbial biomass carbon, microbial biomass phosphorus, and qCO_2 were measured five times from May-October in 2010 under *Triticum aestivum* (L.) (wheat) in both rotations. Seasonal variation was significant for all measurements. Across all sample dates, microbial biomass and activity were higher in the forage-grain rotation.

Table 1.0 Microbial biomass carbon and metabolic activity under wheat across all sample dates. Letters signify within column differences (p<.05). FG (forage-grain); AG (annual-grain)

Agriculture System	Microbial Biomass C (µg-CO_2/g-soil)	Microbial CO_2 (mg-CO_2 /kg-soil/hr)	Microbial qCO_2 (mg-CO_2/g-MBC/hr)
FG No-input	1648a	1.35a	0.77a
FG Organic	1718a	2.11a	0.81a
FG Conventional	1476b	1.00b	0.69ab
AG No-input	1080d	0.73c	00.59c
AG Organic	1115d	0.62d	0.57c
AG Conventional	1179c	0.62c	0.64bc

**values presented are geometric means*

Conclusion:

Agricultural rotation and management significantly affect soil health. Perennial rotations improve soil health by increasing the size and activity of soil microbial populations. Additionally, organic management can amplify the positive effects of perennial rotations on soil health.

Acknowledgments: Thank you to the Canadian Organic Science Cluster for supporting this agricultural research in soil health.

[†] (Macey, Anne and Canadian Organic Growers. Certified Organic Production Statistics for Canada 2008. Ottawa, ON. URL: http://www.cog.ca/our-work/organic-statistics/ (April 2010).

Crop Nitrogen Status and N Use of Potato Cultivars in Organic Farming under Cool Temperate Climate Conditions.

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Background:
For organic potato growers the two main challenges are disease (e.g. late blight caused by *Phytophthora infestans*) and nutrient (nitrogen) management. While frequent applications of copper fungicides may delay the further development of late blight, the often low N status of the canopy may restrict the remaining time for tuber bulking. Knowledge on the crop N status (CNS) therefore may therefore help to avoid useless applications of copper. There is little knowledge on the CNS of organically grown potato cultivars at different crop growth stages nor is there information on the reliability and practicability of methods for its assessment.

Project Overview:
We conducted a two-factorial field experiment (strip-plot design) at the certified organic research farm of the University of Kassel (51.4 N; 9.4 E; 698 mm; 8.5°C mean) on a clay loam (Haplic Luvisol derived from Loess) over three successive seasons (2009-2011) and examined the effect of crop growth stage (60, 70, 80, 90 days post planting (DPP) and at full maturity) and cultivar (18 cultivars) and assessed progress of late blight epidemics (no copper fungicides applied) in the field, crop growth stages (BBCH system), CNS (NO_3 (YARA N-Tester®) and N (Elemental Analysis according to Dumas) in the youngest fully-expanded leaf, NO_3 in stem sap (reflectometric determination using Nitracheck), N uptake by the whole canopy and tuber NO_3 concentration (Nitracheck), nitrogen harvest index (NHI), nitrogen use efficiency (NUE) as well as tuber FM and DM yield.

The experimental season had a marked effect on the incidence and progress of late blight in the field and cultivars examined responded differently in terms of the time and severity of foliage late blight infection. The three-year results allow deduction of cultivar recommendations for farmers that grow potatoes under conditions of either frequent or rare late blight epidemics. However, when the impact of late blight in an individual season on tuber yield is to be quantified, experimental design must consider late-blight-free control plots using state-of the-art copper fungicides. Furthermore, results show that CNS of organic potato crops depends on the cultivar and the method used while markedly responding to the crop growth stage (DPP). Time for CNS assessment should be carried out at an intermediate growth stage, when the maturity type of the individual cultivar does not anymore, or not yet, have an impact. These findings can be used for optimum timing of CNS assessment under conditions of varying N supply (different preceding crops, use of organic manures) in future experiments. Under the same supply of N, crop N uptake, NHI, NUE as well as total and marketable tuber FM yield also differed considerably between cultivars.

Conclusions:
Results of the first two years indicate that the majority of cultivars can be expected to reach maximum total tuber DM yield as early as 90 DPP; which should be considered when decisions on the optimum time for tuber harvest have to be made under conditions of organic farming in humid temperate climate.

Acknowledgments: The financial support of the project by the Federal Office for Agriculture and Food is gratefully acknowledged.

Advances in the Characterization of Soil and Root Arbuscular Mycorrhizal Communities and their Role in Sustainable Agriculture.

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Background:
Emerging knowledge on microbial communities associated with plants indicate that they define, to a significant extent, the life environment of the plant, affect growth and productivity parameters and are a key component to be considered in modern agriculture. Symbiotic associations between plants, microbes and fungi (especially Arbuscular Mycorrhizal Fungi, AMF) provide the plant partner with benefits ranging from enhanced access to nutrients and water, to enhanced protection against pathogens. As we are moving towards a more sustainable agriculture, based on the optimal use of resources, we need to identify the exact components of the microbial community of the soil and root and the mechanisms that contribute to the beneficial effects observed on the plants. What species and what functional features of microbial communities play a role in plant productivity and how can our practices select for these features in the field?

Project Overview:
We aim to characterize the AMF community associated with roots and soil both quantitatively (fungal biomass) and qualitatively (species composition) in space and time throughout the growing season and to identify correlations to crop productivity (wheat) in an agricultural setting in Saskatchewan. We have designed a molecular tool for the quantification of fungal biomass from as little as 200 mg of fresh soil or root material. The tool makes use of a conserved region present exclusively in the mitochondrial genome of many AMF species but absent in other fungal species. As such, the method is specific to this fungal group of interest. Total DNA is extracted from the sample and subjected to real-time PCR amplification and quantification. The amount of target DNA detected in the sample is proportional to the amount of fungal biomass present. We have established standard curves for biomass and amount of target DNA for several AMF species and have validated the tool on in vitro experiments on five different species of AMF as well as in colonization experiments in the greenhouse, on leek plants. We are also surveying AMF biomass and species diversity in wheat roots and soil from a field experiment composed of four distinct fertilization regimes.

Conclusions:
We have optimized procedures for DNA extraction and have designed molecular-based markers for the quantification of AMF biomass in the soil and roots. Our technique can detect down to 1 to 5 spores of AMF or less than 5 ng of DNA per 500 mg of soil or roots and provide estimates of fungal biomass in a sample within a week. The technique is sensitive to the viability and metabolic activity of the fungus and as such can provide essential information about the status of the symbiosis in a particular root sample and provides real-time information about fungal biomass in the soil. We propose that this tool in combination with AMF community characterization may be used to measure the extent of AMF contribution to plant growth in the context of precise soil physico-chemical properties and fertilization regimes and to derive prediction tools for further crop management.

Acknowledgments: Western Ag Innovations, Canadian Wheat Board, Agriculture and Agri-Food Canada, Growing Forward, NSERC, FQRNT, CFI**.**

Can Fungi Replace Fertilizers? The Potential of Mycorrhizal Fungi in Organic Agriculture.

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Background:

The majority of plants have mutualistic root associations with beneficial fungi called mycorrhizae. Depending on the plant host, more than seven different mycorrhizal types have been distinguished. From a practical viewpoint arbuscular mycorrhizae can play a crucial role in agriculture while ectomycorrhizae are important to forestry.

Mycorrhizas increase access of plants to nutrients and water due to the higher surface area of fungal mycelium compared to roots. In addition the fungi mobilize nutrients from the soil that would otherwise not be accessible to plants. Increased nutrient access for mycorrhizal plants leads to healthier plants and higher yields. It was also shown that plants with mycorrhizae have a higher resistance to diseases from soil borne parasites such as nematodes. Mycorrhizae may even buffer plants from excess heavy metals in the soil.

Project Overview:

Mycorrhizal associations are usually present in natural ecosystems and have been utilized in conventional agriculture to some degree. However, it was consistently shown that a high input of mineral nutrients, especially N and P, reduces and suppresses mycorrhizal development. Conventional agricultural soils with a high mineral nutrient level have therefore a tendency to have fewer mycorrhizae associated with roots of crop plants. In contrast, this problem would not arise in soils where organic agriculture is practiced due to generally lower soil mineral levels.

Conclusions:

Crop plants in organic soils under optimal conditions of soil health may already have a high percentage of mycorrhizae in their roots, however, fungal inoculation may be beneficial in soils that were previously exposed to intensive agriculture and therefore still have low densities of mycorrhizal fungi. It is suggested that mycorrhizal inoculation in organic systems would result in a more sustainable and efficient nutrient mobilization as well as improved soil health in comparison to conventional agricultural soils. More research is needed into the degree of fungal colonization in organic soils in the absence of inoculation, the optimal fungal species composition for particular organic crops and the amount of inoculation required for organic systems.

Development of a System for Monitoring of Gaseous Losses During Composting of Solids from Hog Slurry.

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Background:

In Manitoba, phosphorus-based manure management regulations specify the application rate of fertilizer, whether organic or synthetic, depends on the amount of phosphorus (P) in the soil. For producers with limited access to low P soils in close proximity to their livestock operation, separation of swine slurry using centrifugation or rotary press technologies may be a means to concentrate manure P in the solid fraction, providing management options. However, these separated solids require further management to minimize nitrogen losses and odour during storage. Composting the separated solids reduces odours and may stabilize and concentrate nutrients in a reduced volume of material, making it more economical to transport further distances. The objective of this research is to develop a monitoring system capable of continuously monitoring fluxes of nitrogen (NH_3, N_2O, NO, NO_2) and carbon (CO_2, CH_4) gases as well as moisture and temperature of compost.

Project Overview:

The monitoring system developed augments eight LiCor Bioscience automated long-term flux units (LI-8100A) with a multi-gas Fourier transform infrared analyzer by Gasmet Technologies (DX4510) for unattended monitoring of gas fluxes (Figure 1). This system is an improvement to using the static vented chamber method because monitoring is automated so there is a higher frequency of gas flux measurements and it reduces temporal variation. Additionally, the FTIR analysis allows for the measurement of multiple gas analysis in the field. A datalogger and signal multiplexers continuously record moisture and temperature profiles of compost (Figure 2). Results will be presented for gas fluxes and compost conditions from composting of solids initiated in September 2011.

Figure 1. Compost monitoring system

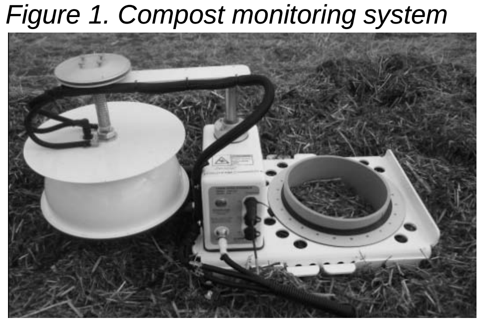

Figure 2. Automated flux chamber unit

Conclusions:

This monitoring system will be used to better understand gaseous losses during the composting process as well as for evaluating beneficial management practices aimed at reducing nutrient losses and emissions of greenhouse gases from composting materials.

Acknowledgments: I would like to thank Western Economic Diversification for funding the project equipment.

Differential Response of Soybean (*Glycine max* L.), Canola (*Brassica napus* L.) and Spelt (*Triticum spelta*) to Organic Amendments.

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Background:
Organic agriculture is a holistic production management system that emphasizes the use of on-farm inputs and the integration of crop and animal husbandries. Limited comprehensive organic agricultural research exists that integrates various interacting subsystems of the organic farm in order to effectively improve its productivity. Organic producers use organic amendments as their major nitrogen source to improve plant, soil and animal health. The main determinants of a cropping plan are its land capability for crop production and local market factors. In this study, we demonstrate that the type of organic amendments available to the organic farm affects its productivity and should be a determinant in the selection of the crops that make up the rotation plan.

Project Overview:
A greenhouse experiment was carried out in 5 L plastic pots containing soils collected from a certified organic farm in Kenilworth, Ontario. The experiment was a 3x3x4 factorial in a strip-split plot design. Crop Species (soybean, canola, spelt), Type of Organic Amendment (beef manure, turkey litter, turkey compost), and the Rate of Organic Amendment (1.2%; 2.4%; 3.6%; and 4.8%, m/m dry weight) were the vertical, horizontal and sub-plot factors, respectively. All four interactions were highly significant. When pooled over organic amendment rates, soybeans grown in soil amended with turkey compost outyielded those grown in turkey litter and beef manure by a factor of 2.1 and 1.5, respectively. In contrast, canola plants grown in turkey litter-amended soils outyielded those grown in turkey compost and beef manure by a factor of 2.5 and 3.2, respectively. For soybean, the maximum yield was obtained in soil amended with turkey compost at a rate of 1.2%; whereas canola and spelt maximum yields were obtained with turkey litter at the rate of 4.8%. The yield response of soybean to increasing levels of the three organic amendments followed a quadratic model, whereas exponential responses were observed for both canola and spelt.

Conclusions:
This study shows that the response of crop species or crop type (leguminous, non-leguminous) varies depending upon the type of organic amendments used. It suggests that the productivity of a farm could be improved by matching the livestock raised in the farm to the crops grown.

Acknowledgments: Thank you to the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), NSERC CRD, Farmers Co-operators, and members of the Organic Meadow Cooperative Grain pool Committee.

Diversity of Arbuscular Mycorrhizal Fungi in Cultivated Soils of the Canadian Prairie.

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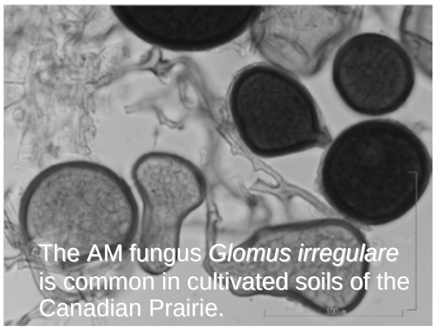
Background:

The risks associated with Global Change are triggering questions about the way we live and feed ourselves. Crop plants' inefficiency at extracting soil nutrients is a primary cause of concern. Residual nitrogen fertilizer fuels denitrifying soil bacteria and the emissions of nitrous oxide, a potent greenhouse gas. Phosphorus fertilizers are used in such amounts as to pollute water ways and deplete world phosphate reserves that are now counted in decades. On this background, organic crop production emerges as a model for the development of sustainable agronomic practices based on ecological principles. Under the light of these ecological principles, crop plants appear as an ecosystems made of plant and microbial components among which the arbuscular mycorrhizal (AM) fungi have evolved as a device for efficient soil nutrient extraction.



The AM fungus *Glomus irregulare* is common in cultivated soils of the Canadian Prairie.

Project Overview:

A main objective of Organic Science Cluster Project A2 is to model the contribution of AM fungi to wheat nutrition in cultivated soils of the Canadian Prairie. As a first step, the diversity of AM fungi living in Prairie soils had to be described, along with the soil environment where they were found, and fields in the main ecozones of the Prairie were surveyed. It soon appeared that the metagenomic methods used to describe AM fungal diversity, as cutting edge as they were would not reveal the identity of the AM fungal species living in the Prairie landscape. The AM fungal diversity encountered in the area surveyed far exceeded the information on AM fungi contained in GenBank, the collection of all publicly available DNA sequences, and the vast majority of the AM fungal sequences found in surveyed soils could not be identified. Because AM fungi only grow in association with living plant roots, trap-cultures of AM fungi were created by growing plants in soil from surveyed fields, and spores were collected through soil sieving and gradient centrifugation for AM species identification based on morphology. Two soil samples out of 38 did not produce any AM fungal growth, but 29 species where recovered from other soils. The most common species encountered were *Glomus irregulare*, *Glomus claroideum* and *Glomus monosporum.* Other species identified were *Diversispora spurca, Entrophosphora infrequens, Glomus clarum, Glomus cubense, Glomus eburneum, Glomus etunicatum, Glomus fasciculatum, Glomus geosporum, Glomus intraradices, Glomus luteum, Glomus microaggregatum, Glomus mosseae, Glomus viscosum, Kuklospora kentinensis, Paraglomus occultum.* Eleven morphotypes belonging to the genera *Glomus* (9), and *Pacispora* (2) could not be identified to the species level. Interestingly, a species of *Peridiospora,* a genera initially thought to belong to the AM fungi, was found in one trap-culture.

Conclusions:

This is one of very few reports on the diversity of AM fungi in the Canadian Prairie, and the most important. AM fungi is being discovered as a tool for sustainable food production.

Acknowledgments: Thank you to Western Ag Innovations, the Canadian Wheat Board, Growing Forward, and Agriculture and Agri-Food Canada.

Phosphorus Availability in Organic Dairy Farm Soils: A Closer Look at the Role of Soil Biology.

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Background:

Recent studies exploring soil fertility on organic dairy farms in Ontario have reported low soil levels of Olsen soil test phosphorus, which is an index of plant-available phosphorus. However, the resultant impact on productivity is not clear. It has been suggested that soil biological activity, including the presence and/or abundance of arbuscular mycorrhizal fungi, in organically-managed systems has an increased role in providing the crop with phosphorus not measured by the conventional soil phosphorus test.

Project Overview:

The objective of this research was to further explore the relationships between Olsen soil test phosphorus, phosphatase activity, arbuscular mycorrhizal fungi root colonization, arbuscular mycorrhizal community structure, and productivity of organic perennial forage cropping. Forage fields on three long-term (>20 yr) organically-managed dairy farms with low soil test phosphorus and relatively high yields were selected and compared with adjacent conventional dairy farm fields with a long-term history of water-soluble phosphorus fertilizer application. Prior to the first forage cut (June 2009), root, plant, and soil samples were collected from each field. Subsequent cuts of hay were obtained over the season to measure total forage yields and phosphorus uptake. The data confirm that forage yields on organic fields were comparable to conventional fields despite having lower soil test phosphorus values. Arbuscular mycorrhizal fungi root colonization was greater in organic systems, which likely contributed to ensuring sufficient crop phosphorus nutrition. An Analysis of Similarity using data generated from Denaturing Gradient Gel Electrophoresis (a molecular biology technique separating sample DNA based on nucleotide composition) images revealed significant differences in arbuscular mycorrhizal fungi community structure between soils under the two management systems.

Conclusions:

This study observed that low soil test phosphorus values did not cause reduced forage yields on organic farms. Increased arbuscular mycorrhizal root colonization likely plays a significant role in maintaining crop P nutrition in organic perennial forage systems with low soil test phosphorus levels. This research demonstrates the crop production potential in organically managed systems and contributes to a better understanding of soil phosphorus fertility and cycling.

Acknowledgments: The authors would like to acknowledge and thank the following organizations for their financial and/or in-kind support that helped make this research possible: NSERC, OMAFRA, Organic Meadow, and the Canada Research Chairs program.

Relative Effectiveness of Organic and Inorganic Nutrient Sources in Improving Yield, Quality and Nutrient Uptake of Canola.

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Background:

In the Canadian Prairies, most soils are deficient in available N, many soils are low in available P, and some soils contain insufficient amounts of available S (mainly in the Parkland region) and available K for optimum crop growth and yield, especially under organic agriculture. There is a great interest and demand for organically-grown food and fibre products in Canada and internationally, but maintaining soil fertility is an important production issue facing organic agriculture in the semi-arid region of the Canadian Prairies. The N deficiency in soil on organic farms can be minimized by growing N-fixing legume crops in the rotations (for seed, forage, or green manure), but in soils deficient in available P, K, S or other essential nutrients, the only alternative is to use external sources, because synthetic fertilizers or chemicals cannot be applied to prevent nutrient deficiencies and increase yield in organic crops. Manure/compost can provide these nutrients, but often there is not enough manure to apply on all farm fields, and the cost of transporting manure to long distances is uneconomical in remote areas. The information on the relative comparisons of organic and inorganic nutrient sources in preventing nutrient deficiencies in the same experiment is lacking.

Project Overview:

A field experiment was conducted from 2009 to 2011 on a Gray Luvisol (Typic Haplocryalf) loam soil at Star City, Saskatchewan, to determine the effectiveness of organic/biological (compost, wood ash [fine, granular], alfalfa pellets, distiller grain, thin stillage, glycerol, fish food additive, *Penicillium bilaiae*), inorganic/mineral (granular - gypsum, rapid release elemental S [RRES], rock phosphate) and chemical/synthetic (granular - ammonium nitrate, triple superphosphate and potassium sulphate) nutrient sources (amendments/chemicals) in improving seed yield and nutrient uptake (N, P, K and S) of canola. In treatments receiving only organic amendments, thin stillage produced the highest seed yield and nutrient uptake, and it was similar to the NPS balanced fertilization treatment. Compared to the control, fish food additive and distiller grain dry of wheat in 2009 and 2011, distiller grain dry of corn in 2009, and compost and alfalfa pellets in 2011 produced significantly higher seed yield and nutrient uptake. In the chemical fertilizer treatments, there was a significant reduction in seed yield and nutrient uptake when only N fertilizer was applied compared to the control, but seed yield and nutrient uptake increased substantially with application of gypsum and RRES, suggesting potential of gypsum and RRES in preventing S deficiency in organic crops. There was little or no contribution of rock phosphate and/or *Penicillium bilaiae* in improving seed yield and nutrient uptake in 2009 and 2010, but in 2011 (third year) application of finely-ground or powder rock phosphate produced significantly greater seed yield than granular rock phosphate, when applied in a combination with N + S.

Conclusions:

Some organic amendments showed potential for improvement in organic crop production. Our findings also suggested potential of gypsum and RRES (inorganic amendments) in preventing S deficiency in organic crops, provided other nutrients are not limiting in soil.

Acknowledgments: The authors thank Western Alfalfa and Sulphur Solutions Inc. for financial assistance and K. Strukoff for technical assistance.

Relative Effectiveness of Various Amendments in Improving Yield and Nutrient Uptake under Certified Organic Crop Production.

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Background:
In the Canadian Prairies, most organically farmed soils are deficient in available N, many soils low in available P, and some soils contain insufficient available S and K for optimum crop yield. In organic farming, inorganic fertilizers/chemicals are not allowed to prevent nutrient deficiencies in crops to increase production, but adequate amounts of nutrients are essential for high sustainable production. Therefore, only certified amendments can be used to prevent any nutrient deficiencies in crops on organic farms. The information on the efficacy of organic nutrient sources in improving yield by preventing nutrient deficiencies in organic crops is lacking under prairie soil-climatic conditions.

Project Overview:
Three-year (2008 - wheat, 2009 – pea, and 2010 - barley) field experiments were established in 2008 on two certified organic farms (tillage summer fallowed in 2007 growing season at Naicam and green manure summer fallowed in 2007 growing season at Star City) in northeastern Saskatchewan to determine the feasibility of amendments (compost, alfalfa pellets, wood ash, rock phosphate, *Penicillium bilaiae*, gypsum and MykePro) and intercropping of non-legume (wheat or barley) and legume (pea) annual crops in improving seed yield and nutrient uptake (N, P, K and S). In 2008, seed yield and nutrient uptake of wheat increased (but small) with compost and alfalfa pellets. In 2009, there was no significant beneficial effect of any amendment on yield and nutrient uptake of N-fixing pea. In 2010, seed yield and nutrient uptake of barley increased substantially with compost and alfalfa pellets and moderately with wood ash. Other amendments had little or no effect on yield and nutrient uptake. Intercropping of wheat or barley with pea produced higher seed yield per unit land area basis compared to wheat or barley grown as sole crops in many cases (on average about 10% less land requirement for intercropping than sole crops).

Conclusions:
Compost and alfalfa pellets (and also cereal-pea intercropping) increased crop yield and nutrient uptake, but other amendments had little effect on these parameters in our study sites. Our results indicated potential benefits in improving yield and nutrient uptake of wheat and barley from compost, alfalfa and possibly wood ash, most likely by preventing deficiencies of some nutrients lacking in the soil under organic farming. Our findings also suggest the need for future research to determine the feasibility of rock phosphate, *Penicillium bilaiae*, MykePro, gypsum, wood ash or other amendments in preventing P and/or S deficiency in organic crops using soils extremely deficient in these nutrients.

Acknowledgments: We thank Western Alfalfa for financial assistance and supplying alfalfa pellets; International Compost Ltd. for supplying Rock Phosphate fertilizers; and K. Strukoff for technical help.

Synchronizing N Supply with Crop Uptake in Spring Wheat Crop Rotations by Altering Green Manure Management Strategies.

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Background:

Synchronizing crop N uptake with soil N supply in organic wheat (*Triticum aestivum* L.) production depends on the incorporation timing and season of green manure. Fall incorporation of the green manure red clover (*Trifolium pretense* L.) has the risk of over-winter N loss to the environment, while spring incorporation could delay the planting date of the subsequent crop. Moderate additions of manure or NH_4NO_3 fertilizer (< 70 kg N ha^{-1}) in the spring may be used in conjunction with fall plowdown to guarantee desired grain yields, yet has the potential to exceed crop N demand and lead to NO_3^- leaching and N_2O emissions. The objective of this study is to assess four green manure management strategies on crop uptake and environmental N loss from a 3-year rotation of red clover (2 years) and spring wheat (year 3) in Truro, Nova Scotia.

Project Overview:

Treatments include; i) early fall incorporation + N fertilizer (70 kg N ha^{-1}), ii) late fall incorporation, iii) above-ground clover removed as hay & residue late fall incorporated + spring manure (70 kg N ha^{-1}), and iv) spring incorporation.

Whole plant wheat yield & N uptake

	Whole Plant Yield	Crop N Uptake	Post Harvest Soil N (0-30 m)
	Mg ha^{-1}	kg ha^{-1}	kg ha^{-1}
Treatments			
early + fert (N_{70})	4.0	121	18.3
late fall	3.4	90	15.8
roots only + manure (N_{70})	3.5	92	14.6
spring	2.8	74	18.6

Whole plant wheat biomass at peak N uptake was greatest from the early fall + N_{70} treatment (4 Mg ha^{-1}) as compared to spring (2.8 Mg ha^{-1}), and N uptake was 121 and 74 kg ha^{-1}, respectively. Post-harvest soil N-min (0-30 cm) ranged from 14.6 to 18.6 kg ha^{-1}, yet were not different among treatments. Nitrate concentrations in drainage water averaged 6.1 to 8.7 mg L^{-1} from November 2010 to June 2011, without any effect of treatment.

Conclusions:

It is clear that the timing of red clover incorporation and the use of supplemental N can significantly affect overall harvest yields and the supply of soil N. Cool and wet spring conditions had a large impact on seasonal N dynamics from the spring treatment, while the two late fall treatments were almost identical, even when above-ground clover was removed and manure was applied at a moderate rate. Post-harvest soil N from the root zone is very low in all treatments, even with the addition of supplemental N at moderate rates of 70 kg N ha^{-1}, yet soil N supply and overall plant yield was the lowest from the spring treatment. Ongoing research is addressing over-winter N_2O emissions and NO_3^- leaching from these treatments.

Acknowledgments: Thank you to the Canadian Agri-Science Clusters Initiative, Growing Forward, Agriculture and Agri-Food Canada, the Canadian Research Chairs program, Royal Bank of Canada Blue Water Program, Nova Scotia Department of Agriculture Technology Development Program, Nova Scotia Agricultural College, Organic Agriculture Centre of Canada, and the University of Saskatchewan.

Livestock Productivity, Health and Welfare

Dairy Cow-Based Measures of Welfare on Organic and Conventional Dairy Farms in Southern Ontario.

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Background:
Assessing animal welfare can provide the first stage of detection for shortcomings in herd health and management and it provides consumers with quality assurance in humane animal treatment. By further identifying those specific management practices that have been shown to affect animal welfare both within and across different systems, more targeted and refined tools and practices can be developed to improve animal welfare.

Project Overview:
An Organic Science Cluster (OSC) project is currently underway in Southern Ontario to benchmark dairy farms using various housing and management practices. Key objectives are to assess both the health and welfare of the lactating cows and examine associations with housing and management practices.

A total of 59 farms were visited between March and May of 2011. Of the farms enrolled, 41 were conventional (12 providing pasture to their lactating cows, 29 having no pasture access) and 18 were organic. The housing systems included tie-stalls (N=35), free-stall (N=18) and pack barns (N=6). Fifteen cows were examined on each farm (5 most recently fresh cows, 10 random cows) for a physical examination of body condition (score 1-5, 1=thin, 5=fat), hock lesions (5 areas assessed, total score range: 0-20, 0=no lesion, 2=broken skin/scab>10 cm^2) and cleanliness (3 areas assessed, total score range:1-12, 1=clean/no manure, 4=filthy, plaques of manure) (N=885).

A mixed model analysis of variance (SAS Proc Mixed) was used to examine how farm level factors (pasture access, organic status, housing system, etc.) and cow level factors (DIM, lactation number, breed) influenced each outcome variable. Body condition scores were lower in organic versus conventional herds (2.27 ± 0.11 vs 2.53 ± 0.11, $P<0.001$) and also for cows in mid lactation ($P<0.001$). Hock lesion scores were higher in conventional herds (3.20 ± 0.14 vs 2.03 ± 0.28, $P<0.001$) and in tie-stall versus free-stall barns (3.00 ± 0.19 vs 2.23 ± 0.21, $P<0.01$). Lesions were also more predominant in cows of higher lactation ($P<0.0001$). Cleanliness scores were higher (i.e. poorer hygiene) in organic versus conventional herds (7.56 ± 0.27 vs 6.18 ± 0.15, $P<0.0001$) and in free-stall versus tie-stall barns (7.49 ± 0.22 vs 6.25 ± 0.18, $P<0.0001$). Associations between the above welfare indicators and amount and duration of pasture use, bedding management and stall design are forthcoming.

Conclusions:
This research will help the dairy industry to identify key practices influencing cow welfare across a variety of management systems and aid in the development of improved on-farm practices.

Acknowledgments: We gratefully acknowledge Agriculture and Agri-Food Canada, Growing Forward and Organic Meadow for providing financial support through the Canadian Agri-Science Clusters Initiative. We also thank CanWest DHI for their assistance in accessing dairy herd information.

Organic Dairy Case Study: Strategies for Somatic Cell Count Management from 38 Quebec Dairy Farms.

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Background:

Milk quality and, more specifically, maintaining a low somatic cell count (SCC), are a constant challenge for the organic dairy producers of Quebec. Valacta statistics have confirmed that along with reproduction, mastitis/high SCC is one of the two leading causes for culling for organic herds. Some organic farms however, have been able to keep their herd average SCC below 220,000 cells/ml for several years. What practices are being used in these herds? Studying these practices will help us to develop a strategy that can be applied to other farms and eventually reduce the average SCC and culling rates in organic herds. It will also be easier to adapt to the upcoming new standards for SCC. By August 2012, all dairy producers in Quebec will be required to meet the new, lower threshold for SCC of 400,000 cells/ml.

Project Overview:

In 2008, a technology transfer project on improving the quality of organic milk was set up in 38 organic dairy farms for a period of three years. Risk factors influencing SCC were assessed using a questionnaire as well as visual evaluations of the cows. Producers received the results of their assessment in an action plan which included several recommendations for improving their practices related to SCC. The two main objectives of the project were: 1–To compare the management practices used on participating farms in order to determine which specific practices were used in herds able to keep their SCC below 220,000 cells/ml. 2–To assess the impact of the recommendations made specifically for each farm. The practices evaluated in this project were grouped into five areas: Cow cleanliness, bacteriology and milking order, milking methods and equipment, dry cow management and resistance of the cow, including genetic selection and nutrition. Results from the first part of the project showed that farms that maintained a SCC below 220,000 cells/ml for three years or more before the project, had excellent management practices in all of the five areas studied. Bacteriology and milking order, as well as cow cleanliness are the two areas that were most often found to be lacking in the herds studied.

Conclusions:

This experience with the 38 organic dairy farms confirmed the importance of taking a holistic approach to SCC by adopting a strategy that covers the five areas of management that were studied. The experience gained on these farms shows that it is possible to improve and obtain milk quality under the organic farming standards.

Acknowledgments**:** Valacta received the mandate to develop this project from the Association of Organic Dairy Producers of Quebec. Project funding came from the Innovbio program developed by the Ministry of Agriculture and Fisheries of Quebec.

Pathogen Identification and Incidence Rates of Mastitis on Organic and Conventional Dairy Farms in Southern Ontario.

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Background:
Mastitis is recognized as a major concern of the dairy industry, resulting in production losses for producers, decreased milk quality and decreased cow welfare. Management of mastitis can be difficult on any farm regardless of system type; the challenge may increase for organic producers who cannot readily employ medicated treatments. It is beneficial to identify commonly occurring mastitis pathogens so that management strategies are tailored to optimize intramammary infection (IMI) prevention.

Project overview:
An Organic Science Cluster project is currently underway on 59 dairy farms (18 organic, 12 conventional with pasture use for lactating cows and 29 conventional without pasture use) in Southern Ontario to survey key aspects of housing systems, producer management practices, health and welfare of lactating cattle and investigate variations in milk composition.

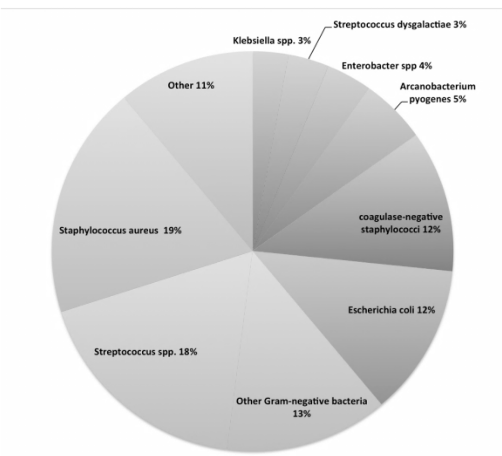

Figure 1: % of total pathogens identified at levels sufficient to cause an IMI

One specific objective of the project is to collect and analyze producer identified clinical mastitis samples with the intent of identifying incidence rates and predominant pathogen types. A clear sampling protocol was developed and reviewed with all producers at the time of an initial farm visit, to standardize case definition and sampling techniques. Clinical mastitis was defined as any change to the normal appearance of milk (for example flakes, clots, blood or watery consistency), from one or more quarters. Producers were asked to record cow identification, date of sample collection, quarter affected and a mastitis score to indicate infection severity. A single sample was to be taken for every infected quarter. Sample collection began March 2011 and is continuing for one year. In the first 25 weeks of the study 458 clinical mastitis samples have been submitted. Well-defined pathogen identification was possible in 71% of samples, of which only 69% were reported to have sufficient bacterial growth to cause an IMI. The types of pathogens identified thus far are found in Figure 1.

Conclusion:
This research aims to identify common pathogens and associated management practices implicated in mammary infections; this information will aid dairy producers' selection of the most appropriate management strategies to maintain production and cow welfare.

Acknowledgments: Thank you to the Canadian Agri-Science Clusters Initiative, Growing Forward, Agriculture and Agri-Food Canada, and Organic Meadow for providing financial support of this project through the Organic Science Cluster. Thank you also to CanWest DHI for their help accessing dairy herd information and DFO bulk milk tank graders for their assistance with bulk milk tank sampling.

Risk for Johne's Disease in Organic and Conventional Dairy Herds in Ontario.

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Background:
Johne's disease is a chronic intestinal disease of ruminants, including cattle. Newborn calves become infected through ingestion of feces, milk or colostrum from infected adult cattle. Organic farming practices support prolonged contact between newborn calves and their dams after birth. It was hypothesized that organic dairy farms could have a higher risk of disease transmission than conventional farms through this neonatal calf management approach.

A standardized Risk Assessment and Management Plan (RAMP) is a core component of the Ontario Johne's Education and Management Assistance Program (OJEMAP) launched in January 2010. The RAMP is administered by trained, private veterinarians. The RAMP is semi quantitative: Low scores to "risk" questions indicate a low risk of disease transmission.

Project Overview:
Between Jan 2010 and Oct 2011, 17 organic dairy farms participating in the OJEMAP completed the RAMP and tested their entire milking herd for Johne's antibodies using milk ELISA. These herds were matched to 2-7conventional farms each (n=45) by herd size and by the veterinarian who did the RAMP.

The overall herd test-positive prevalence was low. The within herd prevalence among organic farms was similar to that of conventional farms. The mean age of cows was also similar between the two farm types. The overall RAMP score did not differ between organic and conventional herds (129.5 ± 40.9 and 123.9 ± 29.4 out of 300 points, respectively). However, in the section "Calving Area Risk Management", organic farms had significantly higher scores than conventional farms (40.1 ± 14.4 and 30.9 ± 10.1 out of 80 points, respectively) indicating a higher risk of Johne's disease transmission in this area.

Conversely, the veterinarians provided considerably fewer recommendations in the area of colostrum and milk feeding management. It might be that the veterinarians felt restricted in their recommendations for Johne's disease prevention due to the common practices and ideals in organic farming.

Conclusions:
Areas of Johne's disease transmission risk unique to organic farms need to be identified and investigated. Current recommendations for disease prevention may need to be modified so that they are compatible with organic practices and can be implemented by organic dairy producers.

Acknowledgments: We kindly thank the University of Guelph/OMAFRA Research Partnership for funding this project.

Effect of Mannan-Oligosaccharides on Innate Immune Response of Broiler Chickens Fed Organic Diet and Challenged *with Clostridium perfringens*.

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Background:
The complete ban or limitation in the use of AGPs causes an increase in necrotic enteritis (NE) which could result in as high as 33% loss in profit to producers. Clinical form of NE is characterized by intestinal lesions, severe morbidity and mortality. Sub-clinical forms of NE, chronic intestinal mucosa damage associated with production losses due to poor digestion, absorption, reduced growth rate and feed efficiency, depression and ruffled feathers are observed. Therefore, the effect of mannan-oligosaccharides (MOS) supplementation in organic broiler diets on performance, gut morphology and innate immunity (gut TLRs and cytokines expression) of broiler chickens challenged with NE producing *C. perfringens* was investigated.

Project Overview:
Three hundred Ross-308 broilers were divided into three treatment groups and fed antibiotic free certified organic starter and grower diets (basal diet provided by Organic Producers Association of Manitoba, Winnipeg, Canada). Treatments consisted of a control no-challenge (CO; 0 g/kg MOS in basal diet), control challenge (COC, 0 g/kg MOS in basal diet), and MOS (2 g/kg MOS in basal diet). On day 14, birds in COC and MOS groups were challenged with 1 ml of *C. perfringens* culture at 3×10^{10} CFU/bird using an oesophageal cannula. Daily feed intake and weekly body weight were measured for all birds. Ten birds per treatment were sacrificed on d22 (post challenge), and jejunum, Ileum and cecal tonsil tissue samples were collected to analyze morphology and gene expression. Challenging of birds resulted in decreased feed intake and BW gain (P = 0.048 and 0.026, respectively). Even though supplementation of diet with MOS improved feed intake compared to CO group (P = 0.985), BW gain and G:F were not improved (P = 0.026 and < 0.001, respectively). There was no significant difference among treatments in jejunal and ileal villus height, crypt depth and goblet cells/mm^2 (P > 0.05). Quantitative real-time PCR showed that, in the ileum, MOS diet resulted in an up-regulation of TLR-2b, TLR-4, IL-12p35, and IFN-γ compared to CO (P = 0.003, 0.018, and 0.024, respectively). In the cecal tonsil, challenging birds with *C. perfringens* resulted in an up-regulation of TLR-2b compared to CO (P = 0.036), while MOS resulted in an up-regulation of TLR-4 (P = 0.018).

Conclusion:
Feeding MOS supplemented diet to *C. perfringens* challenged broiler chickens did not improve performance and gut morphology associated responses. However, alteration of TLRs and cytokine profiles, where dual TLR-2 and -4, with subsequent up-regulation of ileal IL-12p35 and IFN-γ pathways, associated with MOS suggest that MOS supplementation in *C. perfringens* challenged chickens supports a proinflammatory effect via T helper cell-1 pathway. Therefore, MOS supplementation to organic broiler diets can improve immunocompetence of birds under sub-clinical NE outbreaks.

Acknowledgments: Thank you to Manitoba Agriculture, Food and Rural Initiatives, Veterinary Diagnostic Services (MAFRI) for technical assistance.

Exploring the Unique Role of Hairy Vetch in Grazed Green Manure Systems.

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Background:

Grazing annual legume green manure crops offers an opportunity for organic farmers to produce a marketable product (animal products) during a green manure year, while maintaining the nitrogen (N) benefit of the green manure to the following crop. Green manure crops that tolerate grazing (i.e. regrow after grazing) may offer more flexible grazing opportunities and may also improve nutrient cycling in the system. Hairy vetch (*Vicia villosa* Roth ssp. *villosa*) is a highly productive annual legume crop with excellent N-fixing capabilities. It is also unique among annual green manure legumes in that it has the potential to regrow after grazing due to its indeterminate growth habit. Although usually grown as a winter annual, we have been exploring the role of hairy vetch as a spring-seeded annual crop in a grazed green manure system.

Project Overview:

Hairy vetch was produced as a spring-seeded green manure crop at Carman MB from 2007-2011 in mixtures with spring cereals. Average biomass yield of this mixture was over 8000 kg ha^{-1}, making it our highest yielding annual green manure crop. Preliminary observations on the regrowth potential of hairy vetch suggest that regrowth after cutting for hay is variable and depends heavily on moisture availability; however, hairy vetch consistently offered excellent regrowth after rolling with a blade roller.

Grazed green manure trials using sheep were conducted under organic management at Carman, Manitoba in 2009-2011 to observe the effect of grazing on hairy vetch regrowth and on the N uptake and yield of the following crop. In 2009 and 2010, a spring-seeded mixture of hairy vetch and winter triticale (*Triticosecale*) was subjected to various grazing management strategies as well as haying and soil-incorporation (tillage). Spring wheat (*Triticum aestivum* L.) was grown the following year (2010 and 2011) as a test crop.

Hairy vetch regrew successfully after light, short-duration grazing events. Some regrowth was observed after more intensive grazing in some cases, while regrowth after cutting for hay was negligible. In grazing treatments, regrowth appeared to be affected more by trampling of hairy vetch than by forage consumption. Wheat yield in the following year was not affected significantly by any of the treatments, suggesting that there can be considerable flexibility in the management of hairy vetch green manure crops without reducing the green manure N benefit to the following crop.

Conclusions:

Hairy vetch may play an important role in integrated crop-livestock systems due to its high productivity, N-fixing capabilities, and regrowth potential. It may be subjected to various grazing strategies without sacrificing the N benefit to subsequent crops. The ability of hairy vetch to grow either as a winter or summer annual is also unique and may offer further opportunities for its use as an annual forage.

Acknowledgments: Thank you to the Manitoba Rural Adaptation Council and the Canadian Wheat Board for financial support for this project.

Relationship between Urea in Milk and Ammonia Emissions: An Overview.

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Background:

As dietary crude protein is fed to dairy cows in excess of requirement, urinary urea nitrogen levels increase and the urea is hydrolyzed and volatilized by mass transfer to the air above barn floors. This process emits ammonia which can then be rapidly converted to ammonium through a reaction with acidic species, directly contributing to the formation of particulate matter within the atmosphere. A relationship between dietary crude protein intake, milk urea nitrogen, and urinary urea nitrogen levels can be essential. This relationship enables for measurement of urinary urea levels using milk urea levels, and also creates an incentive for the dairy industry to offer premiums when sustainable feeding practices are executed, resulting in milk which meets a regulated value of milk urea nitrogen levels therefore reducing NH_3 emissions.

Project Overview:

Research has shown that as milk urea nitrogen levels declined, so did NH_3 emissions. In 3 stanchion barn studies in Wisconsin and the Netherlands, when milk urea nitrogen levels decreased from 14 to 12 mg/dL there was an average NH_3 emission reduction of 12.4%, and when milk urea nitrogen levels decreased from 14 to 10 mg/dL there was an average NH_3 emission reduction of 24.9%. Meanwhile, within two freestalls in Wisconsin and California, an average NH_3 emission reduction of 13.5% occurred when there was a decrease in milk urea nitrogen from 13 to 12 mg/dL, and an average emission reduction of 27.4% when there was a decrease in milk urea nitrogen from 14 to 10 mg/dL. Deviations among the two results could be attributed to the use of weighted individual milk urea nitrogen rather than bulk-talk milk urea nitrogen, temperature, humidity, and use of different cows (Powell et al., 2008; Aguerre et al., 2011; Powell et al., 2011).

Conclusions:

Some of the research has been conducted on Holstein dairy cows and the emissions are assumed to differ from those of other dairy breeds. Nonetheless, Powell et al. (2011) indicates that the results can be used to create widespread awareness of the relationship between excessive crude protein concentrations in feed and increase in milk urea nitrogen secretions, urinary urea nitrogen excretions, and NH_3 emissions. Controversy exists surrounding the different perceptions of required precision in emission measurements, but some insist that chambers of all types have been used successfully for determinations of relative differences in gaseous emissions of NH_3 (Rochette and Bertrand, 2010). In fact, the research conducted by Powell et al. (2011) indicates that chambers can be used to determine relative effectiveness of management practices on reducing NH_3 emissions from dairy farms.

Food, Sustainability and Organic Systems

Tools for Geospatial and Agent Based Modeling to Evaluate Climate Change in an Agricultural Watershed in Transition to Organic Agriculture.

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Background:
Research confirms that converting from conventional to organic farming reduces GHG emissions on a per ha and per kg basis. These changes are associated with changes in cropping patterns, animal densities and reductions in application of synthetic inputs (Lynch et al., 2011). However, on a regional scale this conversion is a complex process. Outcomes on a landscape level are difficult to predict. The policy and program changes required to support such landscape level changes, and the resulting reductions in GHG emissions, are poorly articulated in Canada.

Project Overview:
Land-use changes are typically modeled using geographic information systems because of the spatial nature of the data. But, the complexity of coupled human and natural systems and the fourth dimension of change over time and time-series data, expose some limitations of GIS tools when used on their own. In this paper, we present the application of a free and open source geospatial Agent-based Model or ABM (also known as a multi-agent model), to the dynamic simulation of key factors required for, and GHG changes associated with, theoretical wholesale conversion of farms to organic production. The model is demonstrated using data from the Middle Maitland Valley, in southern Ontario, a subwatershed with predominantly agricultural land use. We used the RePast platform to develop the ABM. The core of the model is dynamic simulation of small farm enterprise “agents” and their decisions in relation to individual characteristics (e.g., fiscal history and experience with conventional agriculture, willingness to innovate), the agriculture governance environment (e.g., the existence of support for transition) and the economic environment (e.g., market prices for agricultural inputs and products). Small farm enterprises are identified as agents, who make decisions based on individual and environmental parameters and their effects.

Parameters (Driving Forces for organic adoption)		
Farm Agents	***Environment***	***Variables***
Personal Conviction (Social equity, Health)	Farm Finance (Ent. Bud.)	Support for Org. Mkt. Infrast. And Marketing
Personal Experiences of Negative Conventional Negative Effects	Subsidy for Transition	Extension of Transition Advisory Services
Financial Difficulties in Conventional	Avoided Cost Payment	Access to Information-Extension Services
Willingness to innovate to Organic		
Personal Exp. of Successful Org. Farming Model in Watersheds		
Social Network Positive Attention Toward Adoption		

Conclusions:
ABM is a suitable approach to model complex phenomena having both spatial and temporal dimensions. The RePast platform can be used to develop an ABM-GIS model to identify key factors in influencing and supporting small holder farm enterprises to convert their operations to organic agriculture and at the same time estimate the impact on GHG emissions resulting from such conversion. Such a model will be used to develop scenarios representing multiple pathways to organic transition. Parametization of the model can be improved in the future through focus group and collaborative work with farm enterprise stakeholders.

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The Economics of Various Organic Potato Rotations in Atlantic Canada.

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Background:

Fresh fruits and vegetables like lettuce, tomato, broccoli, onion, and potato are the most purchased organic products, accounting for 39% of total organic sales in the US. In Atlantic Canada, the number of organic operations have almost doubled from 74 operations in 2001 to 138 farms in 2006 (Statistics Canada) and organic land accounts for 3,647 hectares. Since over 43% (1.8 million tonnes) of the nation's potatoes are produced in Atlantic Canada, there is significant interest in better understanding the environmental and economic sustainability of organic potato systems.

Project Overview:

An organic potato rotation study was initiated in 2007 in PEI to develop recommendations for organic potato management in Atlantic Canada. Potato rotational treatments consisted of seven 4-year organic rotations and one conventional potato rotation with each phase of each rotation present each year. Organic rotations utilized different crop combinations that included green manure in order to help control pests and maintain nutrient levels. Each rotation included at least two cash crops in a 4-year rotation. Seven organic rotations are: (1) potato(fall rye)-soybean-buckwheat(buckwheat)-brown mustard(buckwheat), (2) potato(fall rye)-fall rye(red clover)-red clover(red clover)-canola(buckwheat), (3) potato(fall rye)-corn(red clover)-alfalfa(alfalfa)-alfalfa(alfalfa), (4) potato(fall rye)-wheat(red clover)-red clover(red clover)-pearl millet(buckwheat), (5) potato(fall rye)-canola(volunteer canola)-oilseed radish(oilseed radish)-sudan grass(buckwheat), (6) potato(fall rye)-pearl millet(stubble)-carrot(barley)-peas/oats(stubble), (7) potato(fall rye)-barley(red clover)-red clover(red clover)-red clover(red clover). And, one conventional rotation is: (8) potato(fall rye)-barley(red clover)-red clover(red clover)-red clover(red clover). Rotation 7 and 8 do not include any of the "beneficial" disease and pest suppressing green manure crops. This paper assessed the economic impact of seven organic potato rotations versus the conventional potato production system. Preliminary yield analysis of only 2008 and 2009 yield data found that organic potatoes in each rotation yielded less as compared to either the conventionally managed potato rotation (27.8 tonnes/ha) or from the average 2008-10 potato yield in PEI (32.4 tonnes/ha). Organic potato yields varied from between 3.8% to 25.6% lower compared to the conventional rotation or from between 17.5% to 36.2% lower compared to the average 2008-10 potato yield in PEI. Rotation 4 produced the highest yielding organic potatoes (3.8% lower than conventional) and rotation 7 yielded the poorest of the organic rotations, with 25.6% less yield than the identical conventional rotation. Statistical analysis did not find any significant differences between rotations; therefore yield comparisons are only trends.

Conclusions: The preliminary results indicated that rotations that included the beneficial green manure crops lead to higher organic potato yields. The rotation that included carrots produced the highest net profits and generally organic potato rotations resulted in higher net profits than the conventional potato system due to the significantly higher price premium received for organic potatoes in PEI. Despite lower crop yields, as long as consumers are willing to pay significantly higher price premium for organic crops in PEI, organic farming is still a viable business. Once 2010 and 2011 data are available, further analysis will be conducted.

Acknowledgments: The financial support of Agriculture and Agri-Food Canada and in-kind contributions from Nova Scotia Agricultural College, PEI Organic Growers Association, PEI Dept. of Agriculture, and University of Manitoba are gratefully acknowledged.

Investigating Soil NO_3^- and Plant N Uptake when Green Manures are Grazed.

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Background:

Organic farmers grow green manures (GM) to supplement soil fertility and for many other benefits. Grazing green manures by ruminants such as sheep can potentially improve the economics when dedicating an entire year to a soil-building crop. Here, we summarize our findings on a three year grazing green manure experiment conducted in Carman, Manitoba.

Project Overview:

We determined the soil and crop responses to sheep grazed and tandem disk incorporated green manures. After GMs (Table 1) in the first year, wheat and fall rye test crops were seeded the second and third years, respectively. In autumn of the GM year, grazed oat and pea/oat plots had significantly more NO_3^- at 0-30cm than incorporated oat and pea/oat plots; 68.2 kg ha^{-1} vs. 28.5 kg ha^{-1} and 138.2 kg ha^{-1} vs. 68.7 kg ha^{-1} respectively. After fall rye harvest in 2011, significant crop by management interaction effect was observed on soil NO_3^-, where grazed hairy vetch plots had more NO_3^- than incorporated hairy vetch plots (47.4 kg ha^{-1} in vs. 34.8 kg ha^{-1}), but, NO_3^- concentration in grazed and incorporated oat and pea/oat were similar. Wheat biomass N uptake was highest in hairy vetch and pea/oat plots, however, there were no significant differences in the yield of wheat. Fall rye biomass N uptake was higher in all grazed plots except in soybean, and yields were significantly higher in the hairy vetch compared with all the other GM plots. Therefore, N benefits from grazing were evident for 2 following crops.

Table 1: Wheat and fall rye yield and N responses, as well as, soil NO_3^- concentrations from 0-30cm and 0-120cm, to grazing and incorporation of various green manures.

Crop	Management	Wheat soft dough N uptake	Wheat grain yield	Wheat grain total N uptake	F.rye soft dough N uptake	F.rye grain yield	2009- soil NO_3^- 0-30cm	2011- soil NO_3^- (0-120cm)
		kg ha^{-1}						
h.vetch	Grazed	148	3370	106	66.2	2813	n/a	47.4
	Incorporated	154	3300	100	54.6	3207	n/a	34.8
pea/oat	Grazed	136	3603	103	56.7	1730	138.2	24.6
	Incorporated	124	3604	99	52.1	2225	68.7	27.6
oats	Grazed	76	3136	76	33.9	1949	68.2	33.6
	Incorporated	63	2950	70	29.2	1423	28.5	37.2
lentil	Grazed	114	3359	92	44.1	1490	n/a	n/a
	Incorporated	114	3281	87	37.5	1299	n/a	n/a
soybean	Grazed	102	3442	91	33.0	1603	n/a	n/a
	Incorporated	123	3647	100	39.4	1605	n/a	n/a
cowpea	Grazed	90	3396	79	42.6	1343	n/a	n/a
	Incorporated	94	2972	78	32.1	2141	n/a	n/a
Source of Variation								
	Crop	0.002	0.313	0.044	0.143	0.029	0.052	0.057
	management	0.886	0.513	0.593	0.037	0.365	0.494	0.424
	Crop x mng	0.682	0.845	0.795	0.33	0.314	0.005	0.049

Conclusions: Grazing green manures increased N availability to following crops, sometimes causing yield increases. As such, grazing by sheep has the potential to augment the value of green manures.

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Relationships between Forage Productivity, Quality, Legume Fixed Nitrogen and Soil Phosphorus Fertility on Organic Dairy Farms.

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Background:
On organic dairy farms, biological N fixation in legume forage crops is a dominant source of N inputs for the farm. In a past survey, we noted that the removal of phosphorus by crops on Ontario organic dairy farms frequently exceeded the inputs of P from manures. This raised the concern that soil P was being depleted on these farms, potentially inhibiting forage crop growth and biological N fixation. The objective of this project was to assess the degree to which low soil P is affecting forage crop growth and N fixation on organic dairy farms in Eastern Canada.

Project Overview:
Over 2008 and 2009, a survey was conducted of soil-test P levels, forage productivity and N fixation on 25 fields on 13 long-term organic or transitional organic farms in Ontario and Nova Scotia. Multiple samples were collected along fixed transects in each field over 2 years. Forage yields averaged 5.8 T ha^{-1} (range of 2.4 to 8.8 T ha^{-1}). Averaged legume content in swards was 53% in Ontario and 24% in NS (range 1 to 84%). N fixation (determined by N isotope natural abundance) in harvested forage was between 10 and 150 kg ha^{-1}, representing 40 to 94% of the legume N.

Approximately three quarters of soil samples were in the low to very low range for soil-test P (below 10 mg P kg^{-1}, Olsen). Tissue P concentration tended to increase with soil-test P up to about 10mg Olsen P kg^{-1} after which the response flattened. At almost all points, forage tissue P levels were between 0.18 and 0.4%. Previous studies report critical minimums of 0.18 to 0.25% for alfalfa and clovers. On 4 of 16 Ontario fields, a weak pattern of increasing yield with increasing soil test P could be observed within points across the field, but overall, there was no correlation between soil-test P and forage yield or N fixation. The majority of fields in the study supplied between 15 and 25 kg P $ha^{-1}y^{-1}$ to the forage crop, despite a high frequency of low soil-test P – perhaps a sustainable soil P supply rate for forages on fields receiving no soluble fertilizer and a modest application of manure every 1-3 years.

Conclusions:
Despite concerns, it is does not appear that low soil-test P is currently a major limitation to forage yields or legume N fixation on the majority of the organic fields of this study. Legume forage crops can perform relatively well when soil-test P is low. However, if crop P removals exceed P inputs in the long-term, the risk of crop P deficiency is likely to increase. To better assess risk, low input and organic farms would benefit from an updated soil testing framework that better estimates the soil P supply in soils that do not receive soluble fertilizers. We propose that such a framework should also consider the role of mycorrhizae and other biological factors that can enhance soil P release and crop P uptake under conditions of low soluble soil-P.

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The Effects of Crimper-Rolled Winter Rye on the Agroecosystem and its Impact on Transplanted Vegetable Crop Productivity.

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Background:
One of the issues of particular concern in organic agriculture is the control of weeds as their presence in the field can lead to important crop yield losses. Producers are challenged to implement weed control methods that do not threaten soil quality and health while maintaining high crop yields. One technique for weed suppression that has shown promising results is the use of cereal rye (*Secale cereal* L.) as a cover crop. In addition to controlling weeds through physical and allelochemical mechanisms, it can provide multiple benefits to the agroecosystem in terms of soil health and insect relative abundance.

Project Overview:
This study has four objectives to determine the effects of crimper-rolled winter rye as a cover-crop on the agroecosystem and its impact on transplanted crop productivity of two different vegetable crops: Broccoli (*Brassica oleracea* L.) variety 'Diplomat' and Spanish onion (*Allium cepa* L.) variety 'Vaquero'. Field experiments will be conducted at the new platform for innovation in organic agriculture of the Research and Development Institute for the Agri-Environment (IRDA) in St-Bruno-de-Montarville, Québec. Both crops, broccoli and onion, will be submitted to four different treatments: (1) transplanted crop in crimper-rolled rye, (2) transplanted crop mechanically weeded (finger weeder), (3) transplanted crop manually weeded, and (4) transplanted crop not treated (control).

The effect of each treatment on the agroecosystem will be assessed by evaluating the microclimate (soil temperature measurements), insect relative abundance (visual scouting for beneficial and insect pests, pit-fall trapping for ground beetles (Carabidae)), weed establishment (weed biomass and count) and vegetable crop productivity (marketable yield by category following Canadian Food Inspection Agency standards). Data will be statistically evaluated by subjecting it to an ANOVA and analysed using the Proc Mixed procedure in SAS. We expect a decrease in weed biomass and an increase in insect relative abundance in the winter crimper-rolled rye treatments thereby positively affecting crop productivity.

Conclusions:
Results of this experiment can give insight into potential ways of improving weed control management by cover crops in south-eastern Canada.

Acknowledgments: Thank you to the Research and Development Institute for the Agri-Environment (IRDA) for providing funding for this project done in collaboration with McGill University.

Impacts of Wheat Stubble Height on Soil Moisture Levels in Different Canola Growing Climate Regions.

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Background:
The global population recently reached 7 billion people, which puts increased pressure to produce more food, fuel and fiber for these additional people. Canada is fortunate in having a large agriculture land base and relatively small population, making the nation an exporter of many different crops. An important crop in Western Canada is canola. It contributes several billion dollars to the economy annually. Since the climate of the Canadian Prairies is semi-arid, moisture is a limiting factor in canola production. If canola yields could be increased by providing better emergence conditions for the crop, this would boost production without adding extra pesticides, fertilizers or genetically modified seed to an agriculture crop.

Project Overview:
It is a relatively simple procedure to cut the stubble of the crop preceding canola at a taller length. This reduces residues on the ground and the taller stubble can allow for more snow to collect on the soil as well as alter the microclimate for the seedlings to better suit canola germination and early growth. The alteration in the microclimate in the canola field provides a mechanical alternative that can potentially increase yields. This project is being replicated over four different climatic regions in Western Canada. One location was in Manitoba at Swan Lake, two in Saskatchewan at Indian Head and Swift Current and one site was located in Grimshaw Alberta. Each site had tall stubble cut at approximately 50 cm height and short stubble cut at 20 cm tall, or had wheat harvested with a stripper header. Gravimetric soil moisture level data was taken in spring before the seeding of the crop and in fall around harvest to determine the remaining moisture levels after the growing season was completed. Soil moisture content was measured at five different depths 0-15, 30-45, 60-75, 90-105 and 105-120 cm to take into account the maximum depth of canola roots. In addition, canola emergence was measured at 24 points, each 1 meter long, for every treatment and counts of canola within these one meter rows were recorded at the second leaf stage. The emergence data and the soil moisture levels will be statistically compared to determine if there is a significant difference between emergence and the soil moisture levels created by the different stubble heights.

Overall Project Goal:
This study will help determine if taller stubble is able to alter the moisture levels to create significant variation in each treatment and in different climatic regions. This can potentially create a positive microclimate alteration that will increase the producer's canola yields and generate more income without adding anymore pesticides, fertilizers or genetically modified seeds to the fields.

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Including Perennials in Rotation with Annuals Reduces Emissions of Greenhouse Gases from Soil.

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Background:

Inclusion of perennial forage in rotation with annual crops is an important strategy to promote internal nutrient cycling in organic cropping systems. Perennial crops also reduce greenhouse gas emission by increasing carbon sequestration and as well as reducing nitrous oxide emissions. However, very little is known about the greenhouse gas emission benefits of including perennial forages in Canadian Prairie cropping systems, or the effect when perennial crops are converted to annual crops.

Project Overview:

The study was carried out within the framework of the Trace-Gas Manitoba project to evaluate short-term and long-term benefits of including perennial forage in rotation with annual crops in terms of cumulative carbon dioxide and nitrous oxide emissions. Carbon dioxide and nitrous oxide gases were continuously measured over perennial and annual crops for four years (2008-2011) by using a micrometeorological flux-gradient method. Figure 1 presents the cumulative flux of CO_2 and N_2O from annual and perennial cropping system over four years.

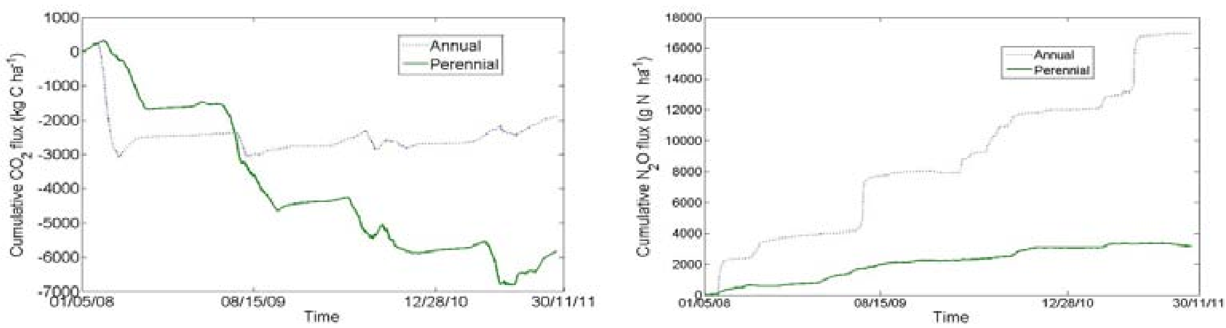

Figure 1: Cumulative C uptake (left) and N_2O emission (right) by annual and perennial cropping system from 2008 to 2011. Positive numbers indicate a loss from the ecosystem to the atmosphere.

Conclusions:

Four years of perennial cropping increased carbon uptake by 4 t C/ha and decreased nitrous oxide emissions by 10 kg N/ha compared to the annual crop for the same period. The perennial forage was killed in 2011 and all plots will be planted to annual crops over the next three years. The greenhouse gas exchange will be continuously measured and net greenhouse gas budgets will be compared between the systems after accounting for harvest removal.

Acknowledgments: The funding for this study was provided by the Manitoba Sustainable Agriculture Practices of the government of Manitoba, the Canadian Fertilizer Institute, the Canada Research Chair Program in Applied Soil Ecology and Natural Sciences and Engineering Research Council of Canada Discovery Program, and the Agricultural Greenhouse Gas Program of Agriculture and Agri-Food Canada. The measurement infrastructure was supported by Canadian Foundation for Innovation grants.

Mycorrhizal-mediated Nitrogen Transfer in a Mixed Legume-Grass Forage Cropping System.

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Background:
Cultivation of mixed legume-grass forage crops often has a central role in organic agricultural production systems because of their ability to convert atmospheric nitrogen (N) to plant N. This N addition represents a significant input in organic production, supplying a major portion of the legume plant's needs as well as those of the associated non-legumes. The role of arbuscule mycorrhizae in transfer of fixed nitrogen from legume to non-leguminous plants was examined for this project.

Project Overview:
Alfalfa (*Medicago sativa*), timothy (*Phleum pratense*) and canola (*Brassica napus L.*) were grown in monoculture and in mixed sward treatments of alfalfa-timothy, alfalfa-canola, and canola-timothy in a greenhouse study. The soil was from a long-term organic legume/grass system. Above-ground plant tissue was taken after 3 months growth, and after 4 weeks growth for the next 3 months. After the final harvest, root samples were collected for measurements of mycorrhizal infection. Harvested plant tissues were analyzed for total nitrogen and for $^{15}N/^{14}N$. The data were used to calculate the N derived from fixation and to provide evidence of the direct transfer of this fixed N from the legume to the grass. In monoculture the $^{15}N/^{14}N$ of the alfalfa indicates access to both atmospheric and soil derived N whereas that of timothy would reflect use of soil N only. In a mixed sward of alfalfa-timothy, the grass also has access to fixed N either from alfalfa residue/root decay and/or from direct, N transfer.

Conclusions:
We estimate that ~40% of the grass N was derived from legume-fixed fixed N via direct transfer by arbuscule mycorrhizae.

Acknowledgments: The authors would like to acknowledge and thank the following organizations for their financial and/or in-kind support that helped make this research possible: OMAFRA, Organic Meadow, Centre for Organic Agriculture.

Organic Fertilization Strategies for Hoophouse Production of Tomatoes (*Solanum lycopersicon* L.) in South Coastal British Columbia.

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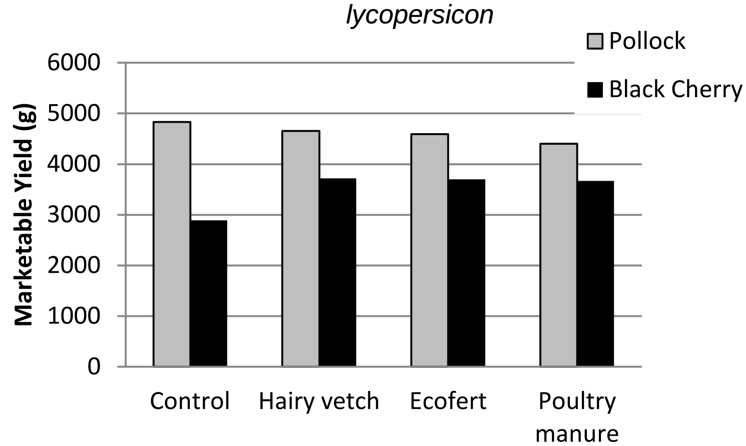
Background:
Cost effective and moveable hoop houses are a suitable technology for intensive production of heat-loving, high-value crops. Organic fertilization programs tailored to these production systems in terms of relative nutrient concentrations, mineralization rates, and pest and disease suppressing capabilities are essential for maximizing productivity and ensuring farm viability.

Project Overview:
Locally available organic fertilizers, including: *Vicia villosa* Roth. green manure, composted poultry manure, and Ecofert® (3-3-4) kelp-based liquid fertilizer, were assessed for use in protected, organic production of *Solanum lycopersicon* L. (tomato) in South Coastal British Columbia. Two cultivars of *S. lycopersicon* 'Black Cherry' and 'Pollock' were grown to assess potential genotype x fertilizer source interactions. All fertilizers were applied at a rate of 100 kg N ha^{-1}. Vegetative growth, yield, fruit quality and plant health associated traits were quantified. The cultivar 'Black Cherry' produced similar total and marketable yields across fertilizer treatments, all of which were significantly higher compared to the control group (Table 1). In comparison, 'Pollock' displayed no significant yield differences across treatments. Preliminary analyses indicate vegetative growth was not influenced by fertilizer source for either genotype. However, differences in yield distribution were observed for cv 'Black Cherry' and are undergoing further analysis.

Table 1. Marketable Yield for Two Cultivars of Solanum lycopersicon



Conclusions:
Preliminary results indicate that no significant differences among fertilizers were present for marketable and total yield. Genotypic differences for fertilizer response were observed for overall marketable and total yields.

Acknowledgments: We would like to thank the Faculty of Land and Food Systems at the University of British Columbia and the Centre for Sustainable Food Systems, UBC Farm for making this research possible. Appreciation also goes to Ecofert Incorporated for their in-kind material support.

Organic Management that Promotes Luxurious Vegetative Growth Lowers Edamame Yield.

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Background:
Soybean (*Glycine max* L. Merrill) "star legume" is the most widely grown and used legume in the world. USA and Brazil dominate the production of grain type soybean while China and Taiwan dominate the production of vegetable type soybean popularly known as edamame. Japan and USA are major importers of edamame. Soybeans, in general, are rich in protein, carbohydrates, dietary fibre, omega -3 fatty acids and other nutrients. Edamame contains more proteins, sucrose and abscisic acids than grain type soybean. The clinical value of soybean against heart disease, cancer, hypertension and osteoporosis is making edamame more popular. Although soybeans can be successfully grown under marginal fertility and moisture regimes, the cultivation of edamame is limited to certain agro-climatic conditions similar to warmer North-West Pacific region. Edamame is described as an "emerging new crop" in European and North American countries.

Project Overview:
A comparative variety performance study of edamame under high fertility irrigated condition (HFIC) and marginal fertility rain-fed condition (MFRC) was conducted during 2011 in Richmond, BC. HFIC was created at Science of Spirituality Eco-centre on loam soil and MFRC was created at Sharing Farm, Terra Nova on clay loam soil. Organic production environments were created through variable amount of city compost with or without irrigation. Six varieties of edamame, three breeding lines from single plant selection of edamame and a grain type variety 'Black Jet' as check were planted on May 26, 2011 and June 15, 2011 on HFIC and MFRC, respectively. Six feet long, three rows plots were spaced 2 ft. apart, maintaining 3' plant spacing.
Canopy height under HFIC was 20-50% more than under MFRC. Pods/plant, 2 and 3-seeded pod types were more under MFRC whereas 1-seeded pod type and seed weight was more under HFIC. Small seeded 'Hidatsa', 'Pando', 'St. Ita' were early maturing followed by medium large seeded Harunamai' and Black Jet. Large seeded three breeding lines and 'Cha Kura Kake' matured late but produced high percentage of 2 and 3-seeded large plump pods than Black Jet. Cha Kura Kake and BL-3 yielded higher under MFRC than under HFIC.

Conclusions:
Selection of proper variety and cultivation under medium fertility organic condition with or without irrigation that controls excessive vegetative growth can give high yield of edamame under agro-climatic condition of Lower Mainland of British Columbia.

Acknowledgments: Sincere gratitude goes to Sharing Farm and Science of Spirituality Eco-centre for providing land and material support for experiment. Special thanks are extended to Salt Spring Seeds Inc., BC and Annapolis Seeds Inc., Nova Scotia for donating seeds.

Perennial Grain Crops and Polyculture: An Ambitious Goal for Organic Agriculture.

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Background:
The ability to sustainably feed the world's growing population is a challenge for all of agriculture. Organic production has moved production towards greater sustainability. However, practices such as tillage and the difficulty in integrating an animal component into the production system, require a different production system. Perennial crop development, coupled with polyculture, provides the potential for sustainable food production.

Project Overview:
Perennial grain and oilseed cropping offers a number of potential advantages over the current annual organic production systems. Relative long-term non-disturbance compared to the current annual organic production systems should reduce the potential for soil erosion and degradation. Perennial grain crops will provide season-long ground cover and have the potential to utilize inputs including water and fertility as they appear in the ecosystem, whereas annual crops have a defined growth term. Perennial polyculture should provide sufficient plasticity to adapt to within-season growing conditions due to the potential for different crop species to predominate depending on the conditions presented. Additionally, perennial polyculture with the inclusion of companion species may: Alleviate competition from undesirable species as currently experienced in all annual and perennial monocultures; provide useful products or by-products for the harvestable species including nitrogen fixing companion crops or for the sustainability of the system; enhance bio-diversity; and/or reduce the potential for catastrophic biotic events. Inter-plant competition impacts performance.

Additionally, perennial crops with limited harvest potential, e.g. a perennial vegetable, will allow for an individual plant to be harvested once, may be included. Under polyculture production conditions, plant-to-plant interactions may be the most important variable with respect to overall stand performance. Combining different plant species into a field will necessitate that, in order for uniform establishment at different sites, individual species will require enough genetic diversity to allow the species to grow in a number of growth environments. Selection under competitive nursery conditions should provide enhanced performance from all component species. Perennial crop development is needed and in concert with polyculture system development, has the potential to provide the long-term, sustainable agricultural production systems required to feed an ever-growing population. Plant, soil microbial and insect diversity will be enhanced.

Non-harvested plant matter may be utilized by animals and deposition wastes will enhance soil fertility and stability. Integration of the perennial cropping and animal systems can be used to enhance both profitability and provide ecosystem benefits and services.

Conclusions:
Potential for an integrated production system with long-term ecosystem benefits though the development of perennial grains and oilseeds coupled with animal production will allow for an increased capacity to sustainably feed the growing population of the earth.

Acknowledgments: Funding for the Perennial Grains Program has been provided by MAFRI-ARDI Program, Canada-Manitoba Growing Forward Program and the University of Manitoba.

Performance Variation of Bush Bean under Different Organic Management Practices.

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Background:

Bean (*Phaseolus vulgaris* L.), a sustainable crop to enrich soil fertility, is an important source of vegetable proteins for human nutrition. Tender pods and beans at various stages are eaten in different forms depending on food habit and culture. The urban markets are dominated by beans produced from agro-chemical farming and transported from long distances raising questions of food mileage, carbon footprint, health risk, loss of heirloom cultivars and local food security. Genetic diversity of bush bean for adaptation to variable environment and traits of agronomic, socio-economic and nutritional importance has made its cultivation worldwide. It is now possible to develop specific agro-ecosystem friendly ethical variety and management practices to address the increasing demand for locally grown organic vegetables.

Project Overview:

Experiments on eleven heirloom (6 dry and 5 snap) cultivars of bush bean were conducted at Sharing Farm under (a) high fertility irrigated (b) medium-fertility rain-fed and (c) marginal fertility rain-fed conditions during 2009, 2010 and 2011, respectively. Different production environments were created by using city compost in different amounts with or without irrigation. Six feet long two row (spaced 2 ft. apart) plots with two replications were planted on May 23, May 28 and June 15 during 2009, 2010 and 2011, respectively to adjust the diurnally fluctuating erratic weather condition of Richmond, BC. All organic production practices were followed.

Results indicated no significant effect of three weeks delay in planting to flowering date. However, early planting under high fertility and irrigation resulted into excessive vegetative growth counterproductive to reproductive growth. Plant height, pods/plant and yield/plant were most affected with little effect on seed weight and no effect on pod length and seeds/pod when grown under marginal condition compared to high fertility and medium fertility condition. Two cultivars of dry bush bean ('Aztec Red-Kidney' and 'Candy') and four cultivars of snap bush bean ('Provider', 'Tanya's Pink Pod', 'Nerrina' and 'Delinel') had healthier growth and produced significantly higher yields of pods and beans under medium fertility rain-fed condition compared to high and marginal fertility conditions. 'Black Turtle Soup' was more stable at all production environments. Result suggested medium fertility organic condition with little or no irrigation for successful production of local organic beans for urban food markets in Lower Mainland of BC.

Conclusions:

Heirloom cultivars of bush bean can successfully be grown at Lower Mainland of BC under proper management practices. High fertility with frequent irrigation and marginal fertility rain-fed conditions are counterproductive for production of bush bean. Selected heirloom cultivars and medium organic fertility condition with little or no irrigation are better husbandry practices for successful production of sustainable high quality fresh local organic beans.

Acknowledgments: I would like to express my thanks to Sharing Farm of Terra Nova, Science of Spirituality Eco-centre and Richmond Food Security Society of BC for providing the land and management support to conduct the study as volunteer scientist. Special thanks are extended to Salt Spring Seeds Inc. for donating seeds for research.

Platform for Innovation in Organic Agriculture: A New Concept in Canada.

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Background:
For many years, the organic agriculture sector has been pointing out the need to develop a site which would be cultivated according to the organic standards. It is well understood that research carried out under organic conditions is more valuable for organic producers. As well, it has many advantages to have research, development, transfer, training and public awareness activities linked together.

Project Overview:
Since early 2006, the Institut de recherche et de développement en agroenvironnement (IRDA - Research and Development Institute for the Agri-Environment) has been actively involved in developing an organic agriculture platform in Saint-Bruno-de-Montarville, on the lands of the former Villa Grand Coteau. This farm of nearly 130 hectares, 90 of which are arable, was operated by the Brothers of Saint Gabriel until 1975, when the provincial government acquired it, later converting it into a research centre. In January 2008, the current owner of the site, the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ - the Quebec Department of Agriculture, Fisheries and Food), entrusted its management to IRDA. In 2008, a feasibility study was conducted on the planned organic agriculture platform. In its conclusions, the implementation of the project was strongly recommended. In June 2008, thirty-two organizations, including organizations from the research, educational, municipal, environmental and biofood sectors, as well as grower associations and agri-environmental advisory clubs, signed a memorandum of understanding about the project demonstrating its strategic importance. This agreement defines a formal framework for partner collaboration on implementation of the concept and activities of this platform. The memorandum of understanding outlines the platform mission and objectives as well as the agreement guidelines and management arrangements. The mission of the organic agriculture platform is to provide an infrastructure and a site that is managed following organic agriculture reference standards so that research, development, transfer, training and public awareness activities associated with organic crop production can be carried out. The objectives of the organic agriculture platform are: To encourage research and development in organic crop production, to facilitate transfer, by transferring knowledge and research results in organic crop production and by offering technical advice and training, to improve general public knowledge about organic crop production and increase awareness of agri-environmental issues, to promote idea sharing and collaboration among organic crop production stakeholders and ultimately strengthen and improve the bio-food capacity of the Quebec organic crop production sector. This platform for innovation in organic agriculture is a major rallying infrastructure project for the entire organic agricultural sector.

Acknowledgments: Thank you to the Ministère du Développement économique, de l'Innovations et de l'Exportation du Québec, the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, and Agriculture and Agri-food Canada.

Greenhouse Production

Organic Greenhouse Cluster Research Activities: An Overview.

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Background:

Greenhouse crop production is a very important segment of the Canadian agricultural industry with a farm value of $2 B and a greenhouse area of ~2000 ha. The main advantage offered by greenhouse production compared with other agricultural systems is the capacity to control year-round growth, thus ensuring very high quality yield as well as a steady supply for distribution networks and consumers. Nonetheless, greenhouse systems are very energy-intensive and account for significant emissions into the environment. Unlike the situation in hydroponics, fertilization decisions in soil-based organic systems involve taking the following aspects into account: Storage, use efficiency, disease resistance and soil well-being microorganisms that help to “nourish” plants. However, according to the soil physico-chemical properties, fertilization and irrigation management, we observed that organic growers may also contribute to important nutrient emission into the ground water. This phenomenon is particularly evident on porous soils when nutrient supply and mineralization rate mismatch plant water and nutrient needs.

Project Overview:

In order to improve the sustainability and yield performance of organic protected crop production systems, research activities were performed within Canada’s Organic Science Cluster in collaboration with 10 partners: Les Serres Nouvelles Cultures, Sagami, Les Serres Jardins-Nature, L’Abri végétal, Les Productions Horticoles Demers, Les Serres Frank Zyromski, La Jardinerie Fortier, Les Serres Lefort, Les Fraises de l’île d’Orléans, Les Tourbières Berger. Research studies were conducted at 9 commercial experimental sites (13 randomized and replicated experimental designs) and 7 research organizations (AAFC Ste-Foy, AAFC St-Jean Richelieu, Horticultural Research Centre of Université Laval, Polytechnique de l’Université de Montréal, SLU Agricultural Sweden University, IRTA-Cabrils, OACC-Nova Scotia University Agricultural College) involving 9 AAFC scientists, 8 university researchers, 4 international researchers, a postdoctoral researcher, 2 university professionals, 29 undergraduate and graduate students, 16 R&D industrial collaborators and 5 consultants.

Conclusions:

Results showed that artificial wetlands can constitute a cheap and sustainable alternative for growers by reducing the N (58-80%), P (65-100%), SO_4 (10-98%), Cl (30-87%) and Na (44-54%) content of greenhouse wastewater as well as plant pathogens such as *Pythium ultimum* and *Fusarium oxysporum*. Optimal environmental conditions were defined for wetlands treating high nutrient load. In addition, suppressive effect of using treated-water against these plant pathogens was observed. Similar results were found by using passive bioreactors. On the other hand, yield and quality of tomato grown in large containers (70-100 L soil per m^2) with or without supplemental lighting were similar to a conventional crop. No negative effect was observed under recirculation. Similarly, transplants of high quality as well as ornamental potted plants grown under organic farming were achieved. Several fertilization trials were performed for different species in order to define the optimal regime. The environmental impacts of an organic tomato growing system were also compared to a conventional system in order to use its environmental profile as a starting point for improving the sustainability of existing and proposed so-called sustainable systems.

Acknowledgments: This research was funded through Canada's Organic Science Cluster, which in turn was funded by the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and its industry partners, Les Serres Nouvelles Cultures, Sagami, Les Serres Jardins-Nature, L’Abri vegetal, Les Productions Horticoles Demers, Les Serres Frank Zyromski, La Jardinerie Fortier, Les Serres Lefort, Les Fraises de l’île d’Orléans, Les Tourbières Berger.

Comparison of Two Cooling and Dehumidifying Methods for a Semi-Closed Organic Tomato Greenhouse.

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Background:
Two non-traditional methods of cooling and dehumidification have been tested to control excess humidity and high temperatures in a semi-closed greenhouse using cold water withdrawals from a saturated water table. The main objectives were to reduce greenhouse air humidity by limiting air exchanges with the outside climate and to increase carbon dioxide levels in the greenhouse in order to stimulate photosynthesis. The first studied method was a cold water fan coil system, where greenhouse air is cooled through a coil on which the water vapour condensates. The second method studied was a cold water curtain technology installed above the crop rows, forcing warm humid air to condensate on the cold-water curtain thus generating a free convection air movement within the greenhouse. These two methods were compared with traditional dehumidifying and cooling methods.

Project Overview:
The total cooling power capacity varied with the systems input conditions (temperature and relative humidity (RH) of greenhouse air and the temperature of the water table). The cooling capacity ranged between 125 and 600 W m^{-2}. The lowest capacity was observed when the ground water temperature was 12ºC and the greenhouse climate conditions were 18ºC and 85% RH. The maximum cooling capacity was observed when the temperature of the ground water was at 6ºC and the greenhouse climate conditions were 31ºC and 80% RH. In order to evaluate the effect of the system on the greenhouse climate a comparison of 3 typical days with similar weather conditions was performed. The water curtain, the fan coil technology and the traditional method were able to maintain set relative humidity and temperature climate conditions in the greenhouse. The water curtain and the fan coil technology were able to maintain high carbon dioxide levels (up to 1000 µL L^{-1}) in the greenhouse by maintaining closed roofs. With the traditional method, the carbon dioxide concentration did not exceed 400 µL L^{-1}, because the roofs needed to be open when high radiation levels were observed. Based on our initial results, the fan coil technology was selected to pursue our study because of its simplicity of use. Another typical day showed that the fan coil technology allowed the removal of water vapour generated by the crop. Based on average plant transpiration of 2.7 L m^{-2} (Turcotte, 2005), the 225 m^{-2} greenhouse generated a total of 607 kg of water vapour. During this day, the fan coil technology was able to condensate 607 kg of water vapour from the air.

Conclusions:
Our results showed that the two non-traditional methods allow the maintaining of desired climate conditions and CO_2 levels in a greenhouse. When using the fan coil technology on typical sunny day, the equilibrium between the transpiration of the plants and the condensation of the coil was possible. The upcoming trials will focus on system optimization and crop response over a yearly production cycle.

Acknowledgments: This research was funded through Canada's Organic Science Cluster, which, in turn, was funded by the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and its industry partners, Les Serres Jardins-Nature and L'Abri Végétal.

Optimizing Fertilisation for Organic Tomatoes and Peppers Grown in High Tunnels.

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Background:
The use of high tunnels for growing tomatoes and peppers is increasing among organic vegetable farmers in Southern Quebec. However, growers and their advisors hesitate to take either a greenhouse-growing fertilisation approach for these crops or an outdoor-growing approach. Therefore, a set of two-year projects were started in 2011 and were aimed at optimizing the fertilisation rates of these crops when grown in high tunnels.

Project Overview:
The experiments are conducted on two on-farm sites located in Wickham (Central Quebec) and in Ripon (Ottawa valley region). In the first experiment, three rates of nitrogen (135 kg/ha, 155 kg/ha and 175 kg/ha of N) are applied to tomato field cultivars 'Mountain Fresh' and 'Oregon' and pepper field cultivars 'Ace' and 'Carmen' as a mixture of compost and pelletized poultry manure in a single application before plantation. In the second experiment, higher dosages of nitrogen (135kg/ha, 195 kg/ha and 270 kg/ha of N) are compared and supplied in a few applications of pelletized manure over the growing season. Foliar and sse analysis are conducted at three times during the season along with a salinity test. General observations on plant health and foliage diseases are noted and the total yields and marketable yields are recorded.

Results of the 2011 season indicate no yield differences at the Ripon site. However, both total and marketable yields of tomatoes were significantly higher at the Wickham site with higher dosages of N (see table). Marketable yields of peppers also tended to increase with higher dosage of N at this site. The response difference obtained between sites may be attributable to a difference in fertilisation history.

Yields of tomatoes at Wickham site

Treatment	Total yield Kg/m^2	Marketable yield Kg/m^2
135 kg N/ha	4,1 a	3,2 a
195 kg N/ha	5,6 b	4,6 b
270 kg N/ha	5,5 b	4,9 b

Conclusions:
Using greenhouse-growing dosages of organic fertilizer may not be always interesting for crops grown in high tunnels. Nonetheless, an estimated increase in net return of approximately four dollars per square meter was calculated with the 195 kg N/ha dosage at the Wickham site. A site-specific approach to fertilisation is advisable.

***Acknowledgments**:* Thanks to the Natural Sciences and Engineering Research Council of Canada, the ministère de la l'Agriculture, des Pêcheries et de l'Alimentation du Québec, Ferme La Berceuse, and Ferme Le Vallon des Sources.

Organic Greenhouse Tomato Production in a Closed System.

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Background:

Environmental concerns have led to major changes within the greenhouse vegetable industry, mainly when it comes to the recirculation of effluent. This is especially important in organic cropping systems where raised bed and reconstructed growing media are used.

Project Overview:

A three-year project was done to evaluate organic tomato production in raised bed containers and the effect of recirculation of effluents on such a system. For the third year of the project, tomato plants were grown in three different growing media: A muck soil (from St-Thomas-de-Joliette) used for a second cropping cycle, "Agromix Bio" (Fafard) an organic peat-based medium used for a fourth cropping cycle and a custom peat based medium containing 5% of clay (Tourbières Berger) used for a second cropping cycle. Tomato plants were grown under independent recirculating systems for each growing medium. Plants were fertilized using certified organic fertilizers following a weekly schedule. Biological activity in the growing media was evaluated periodically whereas three plant biomass and fruit organoleptic quality evaluations were done during the crop.

Overall, yield and fruit quality of this organic tomato crop were considered to be comparable to a conventional crop grown under the same conditions. Also, four bioassays to evaluate the use of rootstocks and mycorrhiza were completed in the same growing media. These bioassays also aimed at evaluating nutrient mineralization and plant uptake following incorporation of different certified organic fertilizers in the medium.

Conclusions:

This project showed that using a peat-based medium in raised bed containers for multiple greenhouse tomato cropping cycles under recirculation of effluents can result in high greenhouse tomato yields. No negative effect on plant development was observed resulting from effluent recirculation or from the observed accumulation of certain salts in the growing media.

Acknowledgments: This research was funded through Canada's Organic Science Cluster, which in turn was funded by the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and its industry partner, Les Productions Horticoles Demers, QC. We are grateful to Jenny Leblanc, Caroline Vouligny and Sébastien Couture who have conducted trials at the commercial experimental greenhouse facility.

Postharvest Infection of Organically Grown Greenhouse Tomatoes Caused by a Range of Fungi in British Columbia.

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Background:

Fungi are the major cause of postharvest spoilage of greenhouse crops such as tomato. Modern hydroponic greenhouses aim to exclude harmful fungi by operating in a sterile environment, including the plant growth and support media. Organic greenhouses use soil-like media for plant growth, and thus they support the growth of soil fungi that have a secondary role as opportunistic plant pathogens causing postharvest spoilage. We were interested to see what organisms were causing an aggressive black spotting of tomatoes in organic greenhouses, and of fungi present on fruit surfaces, which of these were capable of causing infection.

Project Overview:

During 2009 to 2011, tomato fruits were sampled from a commercial organic greenhouse in the Fraser Valley of British Columbia to monitor for disease. Commonly, initial symptoms appeared as minute black spots on the fruit surface. The black spots expanded to form larger gray and yellow lesions with evidence of mycelial growth in the center after 5-10 days of storage. Other fruit showed symptoms of water-soaked lesions and softening followed by mycelial growth. Isolations from symptomatic skin and pericarp tissues from early and expanded lesions onto potato dextrose agar (PDA) yielded species of *Penicillium* including *Penicillium olsonii*. Cultures of *Rhizopus stolonifer*, *Alternaria alternata*, *Cladosporium* and *Geotrichum* species were also recovered. Healthy fruits were inoculated with these isolates and incubated at 21 C. The most prolific infection and decay resulted following inoculation with *R. stolonifer* followed by *P. olsonii*. The latter fruit developed black spots similar to those observed previously. Other recovered isolates of *Penicillium* identified as *P. solitum* and *P. polonicum* caused soft rot and decay similar to *Rhizopus*. During July-November 2011, swabs of growing tomato fruit surfaces and calyx tissues were plated onto PDA. High populations of *P. olsonii* were present (> 40 CFU/ fruit), followed by *Rhizopus*, *Alternaria* and *Cladosporium*. Similar populations were recovered when calyx tissues were plated directly onto media. Wounding significantly enhanced disease severity compared to unwounded treatments for most fungi but not for *P. olsonii*. Entry of *P. olsonii* is likely through naturally occurring cracks of the fruit cuticle from populations that appear to reside in part in leaf litter from prunings that also harbours significant populations of other fungi.

Conclusions:

To our knowledge, this is the first report of a fruit spotting and postharvest decay of tomato fruits caused by *Penicillium olsonii*. It demonstrates the possible sources of inoculum for fruit colonization by various fungi. The growing conditions which may enhance fruit infection have not yet been determined. Storage of fruit at around 10 C does not preclude infection, which can progress further when fruit are shipped to retail outlets.

Acknowledgments: Thank you to Origin Organic Farms, Delta BC for access to tomato greenhouses and for tomatoes for the experiments. Thanks to Village Farms, Delta BC for access to tomato greenhouses. Andrew Wylie is supported by an NSERC Industrial Partnership scholarship with Herio Research Co. Ltd, Langley BC. Additional funding for this project was provided by the BC Greenhouse Growers Association through the Growing Forward program.

Remote Sensing of Nitrogen and Water Status on Boston Lettuce Transplants in a Greenhouse Environment.

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Background:

Remote sensing is the stand-off collection through the use of a variety of devices for gathering information on a given object or area. Applied as a warning tool in plant stock production, it is expected to help in the achievement of better, more uniform and more productive organic cropping systems. Remote sensing of vegetation targets can be achieved from the reflectance or fluorescence properties of vegetation. Both approaches are based on indices that combine certain spectral bands known for the diagnostic information they provide on the condition of vegetation.

Project Overview:

In this study the spectroradiometer FieldSpec® Pro (350-2500 nm), the fluorescence sensor Multiplex®, and the multispectral Camera MiniMCA (450-850 nm) were used to analyze the nitrogen and water spatial variability on Boston lettuce transplants in a greenhouse environment. For each experiment, lettuce transplants were provided by the participating grower about 25 days after sowing and were treated with two nitrogen levels. Prior to remote sensing assessment, they were let to dry or differently watered in order to change their water status. Several vegetation indices were tested to assess nitrogen and water status. The Multiplex parameters FLAV (flavonols) and FRF-UV (Far Red Fluorescence under UV excitation) were found to be the best for discriminating N status while SFR-R (Simple Fluorescence Ratio under red excitation) was strongly significant for the water status. For nitrogen, the best FieldSpec Pro indices were: PSRI (Plant Senescence Reflectance index), DCNI (Double Peak Canopy Nitrogen index) ARI2 (Anthocyanin reflectance index 2), and NIR/R_{660}. For water status: NDWI (Normalized Difference Water index), NPCI (Normalized Pigments Chlorophyll Ratio index), and NDLI (Normalized Difference Lignin index). The camera MiniMCA was used to produce a map of N crop status within a greenhouse with the optimal vegetation index (VI_{opt}). None of the indices tested with the MiniMCA was able to assess water spatial variability.

Conclusions:

It is therefore possible to conceive an early warning system to sense the stress level of an organic transplant crop in the whole space of a greenhouse. The next step is the design of a handy imagery system that could speed-up data collection and processing.

Acknowledgments: This research was funded through Canada's Organic Science Cluster, which in turn was funded by the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and its industry partner, Les Serres Lefort, QC. We are grateful to Gilles Turcotte, Guillaume Proulx-Gobeil and Jean-Pierre Manceau who has supervised and conducted trials at the commercial experimental greenhouse facility.

Biochar Used in Combination with Organic Fertilization for Potted Plants: Its Effect on Growth and *Pythium* Colonization.

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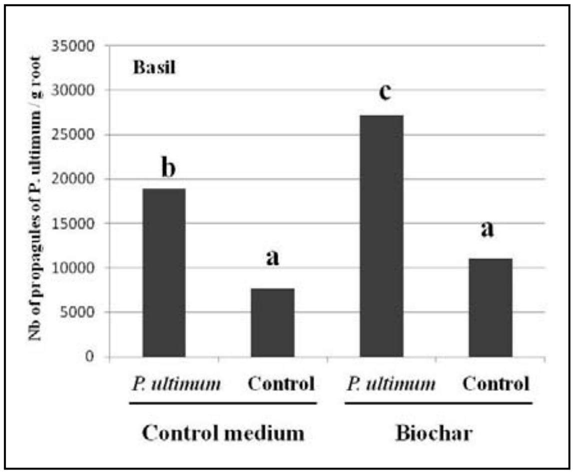
Background:
Benefits that can be drawn from the use of biochar, a byproduct of pyrolysis, in agriculture have been known for a long time. A change in nutrient availability and microbial activity are often related to the effect on plant growth following incorporation of biochar.

Project Overview:
Growth of sweet pepper, basil, coriander, geranium, and lettuce in a peat-based medium containing or not containing biochar was compared. Half of the plants were inoculated with *Pythium ultimum* and all were fertilized using liquid organic fertilizer. Plant biomass accumulation, root colonization by the pathogen and soil biological activity were evaluated.



A higher shoot growth (45% DW) was obtained in the biochar-amended medium for coriander whereas a negative effect (45% DW) was observed for lettuce plants. For *Pythium*-inoculated plants, root colonization by the pathogen was higher in the medium amended with biochar, except for coriander (example of root colonization of basil plants by the pathogen shown). However, even in plants with a higher colonization rate, no visible signs of damage to the root system or to plant development were observed. Soil respiration was lower when biochar was present in the growing medium, which could be related with its specific properties on GHG rather than to a reduction in the biological activity.

Conclusions:
Depending on plant species, high biochar amendment (1:1; v:v) had positive, none or negative effects on growth. Despite the fact that biochar offered a good environment for *Pythium* development, no pathogen damage was observed on the plants.

Acknowledgments: This research was funded through Canada's Organic Science Cluster, which in turn was funded by the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and its industry partner, Les Serres Nouvelles Cultures.

Ornamental Potted Plants: Production under Organic Fertilization.

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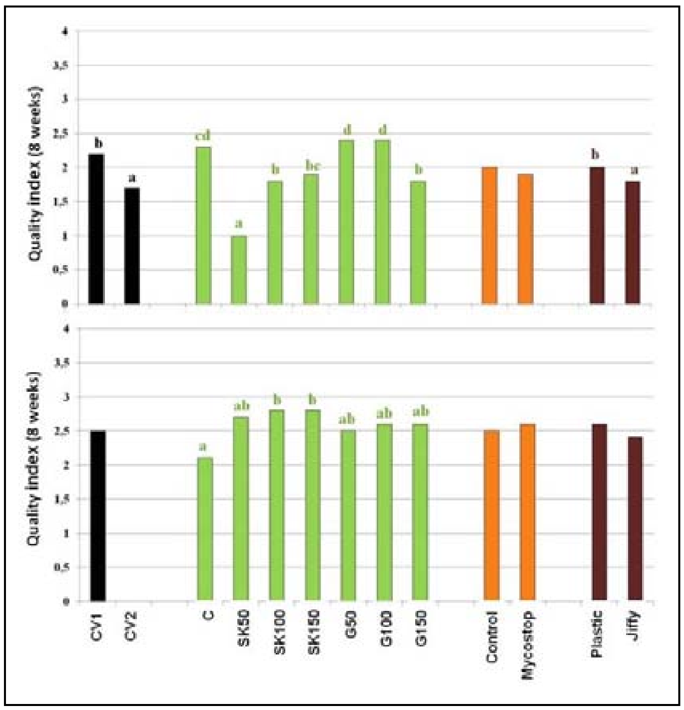
Background :

The ability to grow ornamental crops organically would be an asset for greenhouse growers to meet with the increasing demand of consumers for environmentally friendly products. Ornamental plant quality is directly related to fertilization, especially in organic crops, and must be taken into consideration when developing a production system.

Project Overview:

Seven solid fertilizations were tested: Nutricote (conventional), a mixture of shrimp meal and kelp meal (50, 100 and 150% equivalent of the input from the solid conventional fertilizer) and Gaia Green (50, 100 and 150% equivalent of the input from the solid conventional fertilizer). Plants were inoculated or not with the biofungicide *Streptomyces griseoviridis* (Mycostop®). Two types of containers (10-cm) were also tested: Standard plastic pots and Jiffy peat pots.



Results: Treatment with Mycostop® did not affect quality index (QI) in either plant types. Growth containers only affected QI of impatiens plants.

For that same species, CV2 had a lower QI than for CV1. Impatiens plants that received fertilization SK150, G50 and G100 had a similar QI than conventional plants. By 8 weeks, a high mortality rate was observed for petunias CV 2 whereas for CV1, QI was in general higher for plants that received organic fertilizers compared to conventional.

Conclusions:

Overall, a strong cultivar effect was observed for all species and the effects were also highly species dependent. Nevertheless, both petunias and impatiens plants with a similar quality than conventional could be obtained using organic fertilization.

Acknowledgments: This research was funded through Canada's Organic Science Cluster, which in turn was funded by the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and its industry partner, Les Serres Frank Zyromski, QC. We are grateful to Nicolas Zyromski who has supervised all trials at the commercial experimental greenhouse facility.

Composts and Forestry Industry Waste as Peat Moss Substitutes in Greenhouse Growth Media.

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Background:
Commercial greenhouse growing media is primarily peat-based. The cost of peat moss and the environmental implications of peat harvesting are driving an industry demand to find a cost-effective and environmentally friendly peat replacement. Using wood waste and compost from the forestry industry, we evaluated the suitability of different blends as a peat replacement in commercial greenhouse growing media.

Project Overview:
Black earth compost, pulp fiber, and aged softwood bark were supplied by Envirem Organics Inc., Fredericton, NB. Blends were created on a volume basis. Eleven blend compositions were used with 100% peat moss used as a control (Table 1) and lime was added to adjust the pH of each blend to an optimum range. Tomato (*Solanum lycopersicum* var. Scotia) seedlings were planted and after 7 weeks plants were harvested and biomass of roots and shoots were recorded. Nitrogen content of tomato shoots and roots was analyzed.

Table 1: Composition of blends.

Blend	Peat	Perlite	AWB (coarse)	AWB) (coarse + fine)	Pulp fiber	Black Earth
1	60%	20%	-	-	-	20%
2	50%	30%	-	-	-	20%
3	60%	-	20%	-	-	20%
4	50%	-	30%	-	-	20%
5	40%	-	40%	-	-	20%
6	60%	-	-	20%	-	20%
7	50%	-	-	30%	-	20%
8	40%	-	-	40%	-	20%
9	60%	10%	-	-	10%	20%
10	60%	-	10%	-	10%	20%
11	40%	-	-	30%	10%	20%

Blend significantly affected plant biomass ($p<0.0001$). The peat only control had significantly higher biomass over almost all blends. Nitrogen uptake was also signifcantly affected by blend ($p<0.0018$). Again, the control outperformed all blends. Blends 1 and 2 tended to perform better than other blends in both biomass and nitrogen uptake. This could be due to the higher percentage of perlite in blends 1 and 2, resulting in improved aeration of the growth media. Blends with a higher percentage of peat also showed slightly better N uptake.

Conclusions:
A higher proportion of peat and proper aeration will likely increase the performance of the blends. Further studies are ongoing to test different ratios of coarsely screened aged wood bark, perlite and peat. The use of wetting agents and consistent fertilizer application will provide a better comparison with professional growth media already on the market.

Acknowledgments: Funding was provided by Envirem Organics Inc., the Atlantic Innovation Fund, the Canada Research Chairs Program, and the Career Focus program though Agriculture and Agri-food Canada.

Enrichment of Artificial Wetlands with Biochar to Improve their Efficiency and Reduce N_2O Emission.

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Background:

Greenhouse effluents, whether from organic or conventional systems, are usually highly charged with nutrients. During one year of growing tomato plants we observed that effluent from an organic crop grown in containers greatly varied according to the fertilization management and time of sampling but could reach 400 ppm N, 111 ppm K, 26 ppm P, 90 ppm Ca, 31 ppm Mg, 743 ppm SO_4, 4 ppm Cl and 375 ppm Na. In production systems where recirculation is not used, volume of drained solution rejected in groundwater can cause significant environmental burdens. Recently, we have shown that artificial wetlands can constitute an interesting alternative for growers by reducing the N (58-80%), P (65-100%), SO_4 (10-98%), Cl (30-87%) and Na (44-54%) content of the greenhouse wastewater. However, we observed that emission of N_2O from horizontal subsurface flow wetlands can be much higher than soil amended with cow or pig manure. Adding biomass-derived black carbon (biochar) to the filtering medium in constructed wetlands may be an option to improve nutrient removal.

Project Overview:

The objective of this study was to evaluate the efficiency of biochar as a filtering medium to reduce the charge in nutrients (N, P, SO_4 and Na) of organic greenhouse effluents and GHG emission (N_2O). Thirty-six wetland units (0.88 m^3 each) implanted with *Typha latifolia* were built in order to compare 6 treatments (2x3) in 6 replicates: Gravel or coarse sand without (control) or with 15% Biochar (as a layer filter of 20 cm wide x 71 cm deep) or incorporated to the filling media; 15% v/v; Balsam fir + white and black spruces; pH 7.1, EC 0.38). The following parameters were measured: EC, pH, pollutant load (anions and cations), COD, TOC, greenhouse gas emission (CO_2, N_2O and CH_4), total microbial activity, denitrifying microorganisms, sulphate reducing bacteria as well as macrophyte growth. Preliminary results showed that microbial activities as well as the efficiency to reduce pollutants were higher in wetlands filled with gravel compared to sand. For elements of environmental interest such as nitrate and phosphate, all types of wetlands have reduced their amount by almost 100% after 2 months (Figure 1). N_2O and CO_2 flux were almost nil and did not vary according to the wetland filling material or biochar treatments at the low nitrogen content of the organic effluent.

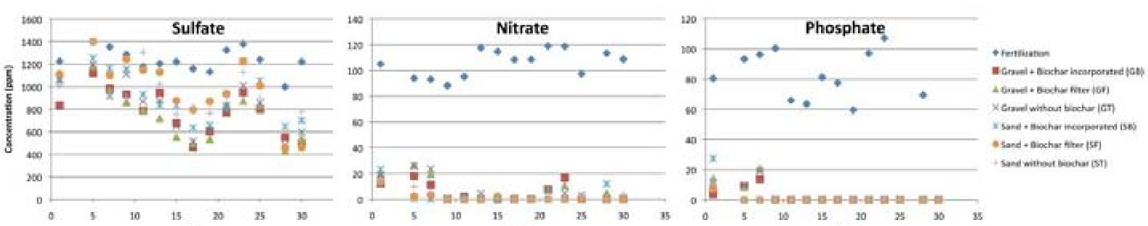

Figure 1 Evolution of the sulfate, nitrate and phosphate concentrations measured in treated organic greenhouse effluents during 30 weeks compared to the influent (fertilization; runoff solution).

Acknowledgments: This research was funded through Canada's Organic Science Cluster, which in turn was funded by the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and its industry partner, Les Serres Nouvelles Cultures. We are grateful to Normand Bertrand, Claudine Ménard, Édith Tousignant and Réjean Bacon for their contribution to this project.

Environmental Assessment of an Organic Integrated Greenhouse Tomato Crop Grown Under Northern Conditions Compared to a Conventional Crop.

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***Background*:**
The environmental burdens associated with fossil energy use, in addition to water and fertilization management continue to be major concerns for Northern greenhouse production systems. To reduce the environmental impacts of greenhouse farming under Northern climate conditions, the use of renewable energy sources and suitable nutrient and waste management are becoming essential. From this perspective, a closed-loop organic production system that increases the efficiency of water and nutrient use on-farms and utilization of waste biomass was tested in the province of Quebec.

Project Overview:
The goal of this study was to assess the environmental impacts of this integrated system compared to a conventional system in order to use its environmental profile as a starting point for improving the sustainability of existing systems. The environmental analysis was conducted with LCA methodology as defined by ISO 14040 and 14044, the ILCD handbook (2010) and SimaPro v.7.3.2 software. The functional unit was 1 ha but results were also expressed in kg of tomatoes (yield of conventional and organic growing systems were 50 kg/m^2 and 48 kg/m^2, respective). The system boundary was from raw materials extraction to the farm gate. The life cycle stages considered were the infrastructure, auxiliary equipment, climate control system, farm operation, fertilizers, pesticides, waste management and packaging. One energy flow indicator (cumulative energy demand) and five impact categories, defined by the CML2001 method v. 2.05 (Guinée, 2002), were selected for the environmental assessment.

Conclusions: From the environmental assessment indicated, as expected, that high energy demand had the major contributions to all impact categories (Figure 1). When organic farming using wood biomass as renewable energy was used, the CO_2 footprint of one kg of tomatoes was reduced from 5.788 to 0.849 kg CO_2 eq/ kg compared to the conventional growing system. After packaging, greenhouse structure made the third highest contributions to environmental impact categories. The fertilizer assessment of the organic crop had a lower environmental impact on abiotic depletion (by 12 times), acidification (by 6 times), eutrophication (by 136 times) and global warming (by 10 times) compared to the conventional fertilizer assessment (data not shown).

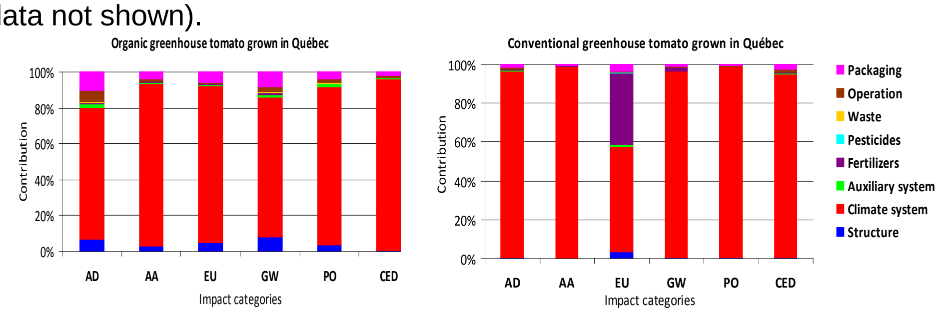

Figure 1 Stages contributions to impact categories for organic and conventional greenhouse growing systems: AD, abiotic depletion; AA, air acidification; EU, eutrophication; GW, global warming; PO, photochemical oxidation; CED cumulative energy demand.

Acknowledgments: This research was funded through Canada's Organic Science Cluster, which in turn was funded by the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and its industry partners.

Organic Fertilization and its Effect on Development of Sweet Pepper Transplants.

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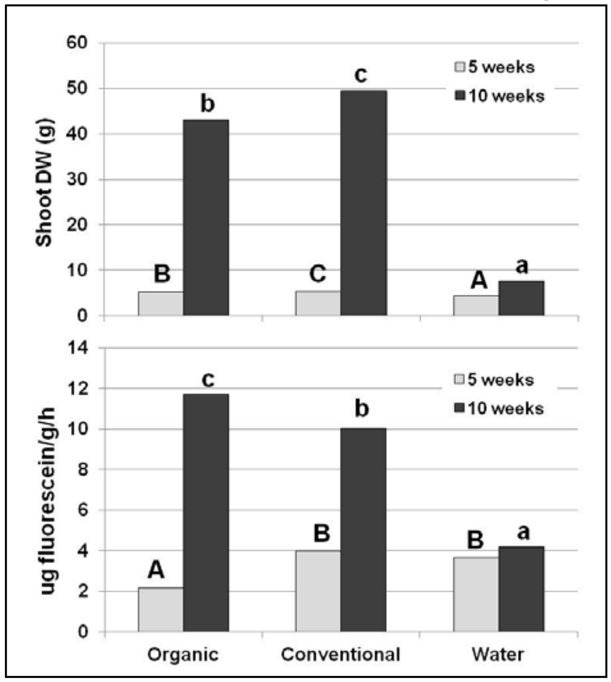
Background:
Organically-grown greenhouse sweet pepper crops, as is the case with most year-round greenhouse crops, rely on pre-grown transplants. Production of adequately balanced (source and sink strength potential) healthy organic sweet pepper transplants is a challenge, and is often related to early and total harvested yields.

Project Overview:
Shrimp meal (0, 400, 800 or 1600 mL m^{-3}) and Kelp meal (0 or 50 mL m^{-3}) were incorporated in the growing medium. Transplants were inoculated, or not, with a beneficial microbial agent, *Trichoderma harzianum* Rifai strain KRL-AG2 (Rootshield®) and grown under greenhouse conditions. After transplanting, sweet pepper plants received water, conventional synthetic fertilization or liquid organic fertilization.



Medium respiration (CO_2 efflux) and FDA hydrolysis analysis showed a higher microbial activity in the liquid organic fertilizer treatment. Transplants that received liquid organic fertilizer had greater development compared to transplants that only received water in addition to the initial solid fertilizer. However, organic amendment mineralization did not completely fulfill transplant nutrient requirement compared to conventional transplants. Inoculating a beneficial agent to the organic growing medium increased its biological activity but had no effect on seedling growth.

Conclusions:
Use of solid organic fertilization (1600 mL m^{-3} of shrimp meal with 50 mL m^{-3} of kelp meal) and of organic liquid fertilization should be used, in combination with inoculation with *T. harzianum*, to obtain high quality organic sweet pepper transplants.

Acknowledgments: This research was funded through Canada's Organic Science Cluster, which in turn was funded by the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and its industry partners.

Organic Production of Vegetable and Herb Transplants.

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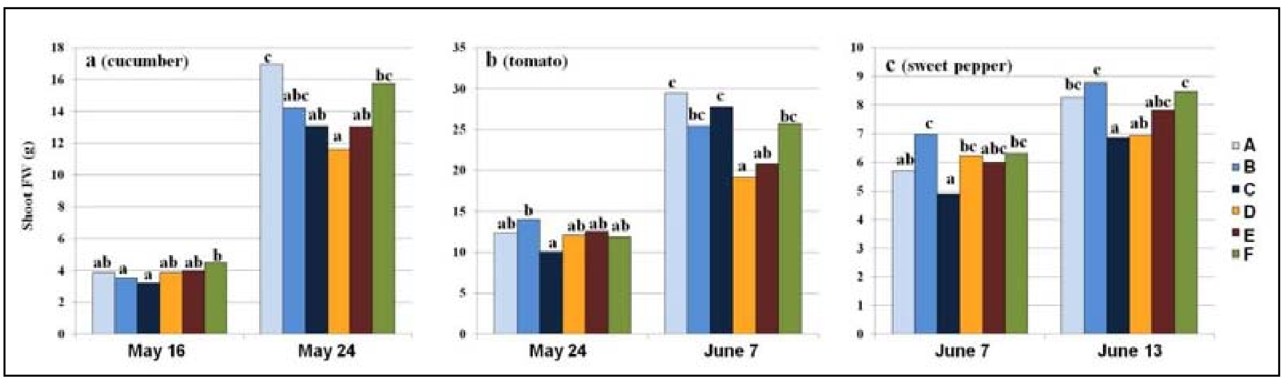
Background :
Demand for organic vegetable transplants, whether coming from vegetable growers or home gardeners, has increased significantly in Canada. As growth of seedlings is highly affected by substrate physical properties, elaborating an adequate fertilisation based on solid amendments is crucial to obtain quality transplants. A project was undertaken at Jardinerie Fortier to develop an organic greenhouse production system for vegetable and herb transplants.

Project Overview:
Six solid fertilizations were tested: A complete fertilizer recipe consisting of crab meal, kelp meal, compost, bat guano and feather meal (A: 50%, B: 100% and C: 150% of recommended concentrations); D: crab meal and kelp meal only; E: crab meal, compost and kelp meal only; F: crab meal, kelp meal, compost, and feather meal only. Two plant evaluations were done for each plant type (11 to 39 days following transplanting). Each time, plant quality and biomass were evaluated. Plant biomass tends to decrease with an incomplete fertilizer recipe, with treatment B having the lowest biomass accumulation. Fertilization A, B and C resulted in a similar biomass for all three species.



Conclusions:
These results showed that half of the concentration of the complete fertilizer recipe resulted in quality vegetable transplants. Most significant differences were observed when plants had reached marketability when solid fertilizers were becoming sparse.

Acknowledgments: This research was funded through Canada's Organic Science Cluster, which in turn was funded by the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and its industry partner, La Jardinerie Fortier, QC. We are grateful to Jonathan Fortier who has conducted all trials at the commercial experimental greenhouse facility.

Organically-Grown Greenhouse Tomato Under Supplemental Lighting.

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Background:

Because light is a key limiting factor for plant productivity and fruit quality in greenhouse crops, supplemental lighting (SL) under organic farming could constitute a promising alternative to satisfy Canadian consumers' demand for organic and local vegetables. However, previous studies on SL have been conducted mainly with conventional crops and only a few observations are available for organic crops where nutrients may also be a limiting factor for crop productivity.

Project Overview:

The purpose of this study was to adapt an organic growing system to SL. A split-plot experiment was performed in a commercial greenhouse (Serres Sagami, Chicoutimi, QC) to determine the effects of row spacing (main plots: 3 rows per bay vs. 4 rows) and growing system (sub-plots: conventional vs. organic) on plant growth parameters, carbohydrate partitioning, mineral nutrition, tomato yield, and fruit quality. Seedlings of *Solanum lycopersicum* (cv Heritage grafted on Beaufort) were transplanted in 15-liters coco coir slabs vs. containers with 100 L m^{-2} organic soil and grown under SL (HPS lamps; ~100 µmol m^{-2} s^{-1}, 14-16 h photoperiod) and 650 µL L^{-1} CO_2 for six months. Plant density was similar between row spacing treatments and the irrigation management was based on soil matric potential measured at 15 cm depth using wireless tensiometers and an irrigation set point of –2.8 kPa.

Conclusions: Measurements of SL at plant height (~1.7 m from HPS) and near the 5th leaf (~2.5 m from HPS) with a line Quantum showed no significant difference in PPFD (mean: 95 and 82 µmol m^{-2} s^{-1}, respectively) between the two row spacings. Nitrate concentrations in the soil solution were significantly lower for the organic crop (50-200 µL L^{-1}) than the conventional growing system (1000-1200 µL L^{-1}). Despite low levels of nitrate in the organic soil, there were no significant differences in measured plant growth parameters compared to the conventional system. Tomato yield did not differ significantly between the organic and conventional crop system after 29 weeks of production, even though a higher yield (~2.5 kg m^{-2}) was produced under the organic regime. Further, row spacing had no effect on cumulative yield within each growing system. Our results will be discussed in terms of fertilization management, plant growth, carbohydrate partitioning, yield and fruit quality under SL. We will conclude on the sustainability of using SL for an organic greenhouse production.

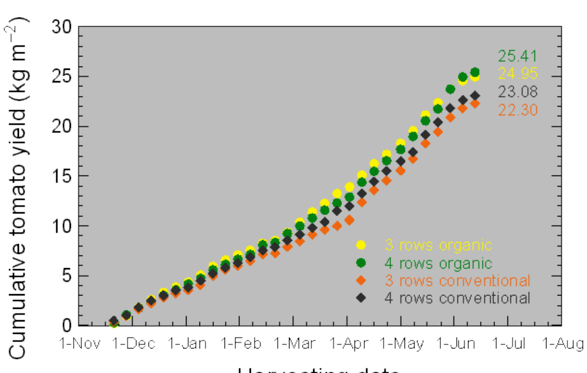

Figure 1. Evolution of the marketable tomato yield during 29 weeks of production.

Table 1. Tomato fruit quality harvested in March and April. No effect of row spacing was observed, while fruits from organic farming was slightly reduced compared to conventional growing fruits.

Fruit quality parameters	Organic crop		Conventional crop	
	15 March 2011	*19 April 2011*	*15 March 2011*	*19 April 2011*
Soluble sugars (%)	3.17 (± 0.06)	3.80 (± 0.35)	4.63 (± 0.49)	4.80 (± 0.40)
EC (mS cm^{-1})	5.08 (± 0.37)	4.72 (± 0.32)	4.50 (± 0.36)	4.79 (± 0.25)
Lycopene (mg kg^{-1})	37.78 (± 1.70)	41.29 (± 2.40)	43.91 (± 4.09)	48.87 (± 4.20)
Titratable acidity (%)	0.40 (± 0.03)	0.38 (± 0.01)	0.40 (± 0.04)	0.42 (± 0.02)
Antioxidant (TEAC)	0.99 (± 0.06)	1.38 (± 0.21)	1.49 (± 0.20)	1.76 (± 0.60)

Acknowledgments: This research was funded through Canada's Organic Science Cluster, which in turn was funded by the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and its industry partner, Les Serres Sagami. We are grateful to Gilles Turcotte, Édith Tousignant and Caroline Dalpé for their contribution to this project.

A Passive Biological Approach to Remove Plant Pathogens from an Organic Greenhouse Effluent.

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Background:

Due to the lack of high quality water and potential pollution of groundwater by leached nutrients, recirculation or treatment of agricultural wastewater is now unavoidable. Even though recycling growing systems offer several advantages from an environmental point of view, risks associated with pathogen spread, unbalanced nutrient solutions and build-up of phytotoxic compounds are major concerns for growers. Moreover, conventional approaches to treat effluents coming from organic crops are often not efficient due to their high content in organic matter.

Project Overview:

Therefore, the objective of this study was to evaluate the effectiveness of three types of artificial wetland to reduce the population of *Fusarium oxysporum* and of *Pythium ultimum* in greenhouse effluents. To do so, an experiment was conducted under greenhouse conditions using horizontal subsurface flow artificial wetlands (HSSF-AW) filled with pozzolana and implanted with common cattail (*Typha latifolia*). Wetland units contained either 1- sucrose (AWS), 2- compost (AWC) or 3- no external (AW) carbon source. The experimental design was a complete randomized block design with four replicates (total of 12 e.u. of 0.08 m^3) and a retention time of 5 days. Wetland units received a reconstituted greenhouse effluent and, were weekly inoculated with a suspension of *Fusarium oxysporum* (10^6 CFU per mL) or of *Pythium ultimum* (10^6 CFU per mL). Daily samples of AW-effluent were collected and *F. oxysporum* and *P. ultimum* concentration was evaluated using the selective Komoda and PDA-PARP media, respectively. Total organic carbon, biofilm, cell wall degrading enzyme (CWDE) and populations of mesophilic bacteria, *Pseudomonas* spp., and *Bacillus* spp. were evaluated. Results showed that each type of HSSF-AW was efficient to reduce by 99.9% measured population at the effluent level. Physical, chemical and biological removal mechanisms as well as environmental conditions were evaluated to explain this observed high removal percentage. The compost amendment (AWC) promoted the biofilm development around the filter media and wall degrading enzymes (CWDE), which played a role for plant pathogen removal. The relative importance of the different processes (biofilm adsorption, CDWE, antagonistic properties) is hardly definable, mainly due to the fact that the effective processes may interact. However, processes involved varied according to the AW carbon content. Compost amendment (AWC) allowed a better biofilm formation and CDWE production, while microflora with antagonistic properties (*Bacillus* spp. and *Pseudomonas* spp.) was more numerous when sucrose (AWS) was provided. Nevertheless, AWs without any exogenous source of carbon were as effective to eliminate studied plant pathogens as enriched carbon artificial wetlands.

Conclusions: This study showed for the first time that HSSF-AW may constitute a sustainable alternative method to remove plant pathogens from the greenhouse effluent with a removal efficiency of 99.99%, which is an acceptable threshold for the industry.

Acknowledgments: This research was funded through Canada's Organic Science Cluster, which in turn was funded by the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and its industry partner, Les Serres Nouvelles Cultures. We are grateful to Valérie Gravel, Claudine Ménard, Édith Tousignant and Réjean Bacon for their contribution to this project.

Soil Oxygen Enrichment in Organically-grown Greenhouse Tomato.

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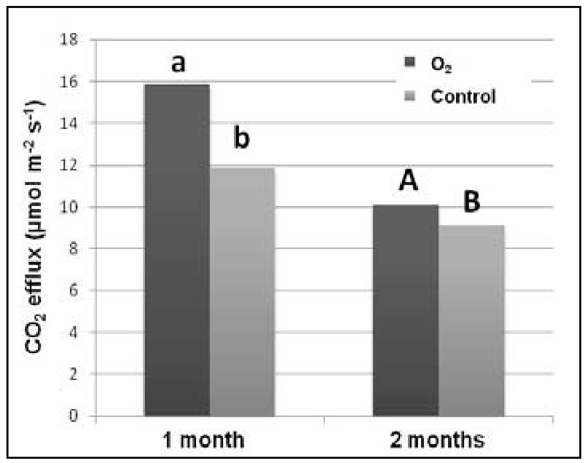
Background:
Stimulation of soil biological activity, which is directly related to mineralization rate, is known to affect organic greenhouse production. Benefits from soil oxygen enrichment have recently been shown in soil-bound greenhouse tomato productions.

Project Overview:
The objective of this study was to evaluate the effect of a combination of soil oxygen enrichment and recirculation of effluents on the development of a tomato crop in six organic soils with different physical properties: 1) sandy soil, 2) a mix of peat, sawdust and compost (30:60:10), 3) a mix of blonde peat and compost (90:10), 4) sandy loam, 5) loam, and 6) muck soil. Ten grafted tomato plants (*Solanum lycopersicum*) were cultivated in each growing container. Certified organic compost, crab meal and seaweed extract were used as fertilizers. Soils were enriched with oxygen through an injection system installed at the bottom of each container.



Overall, oxygen enrichment increased biological activity, measured as CO_2 efflux, within the soils tested and in some cases increased nitrate availability. A negative effect of oxygen enrichment on tomato yield of mature plants was observed at the end of the crop. However, fruits produced in oxygen enriched soils had a higher lycopene content (P=0.0172).

Conclusions:
Even though no positive effect on plant growth was observed, soil oxygen enrichment can be beneficial to organic greenhouse production through an increase in the soil biological activity, a higher nutrient availability, and a higher fruit quality.

Acknowledgments: This research was funded by the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ) through the "Programme de soutien au développement de l'agriculture biologique".

Soil Salinization of Organically-grown Greenhouse Tomato.

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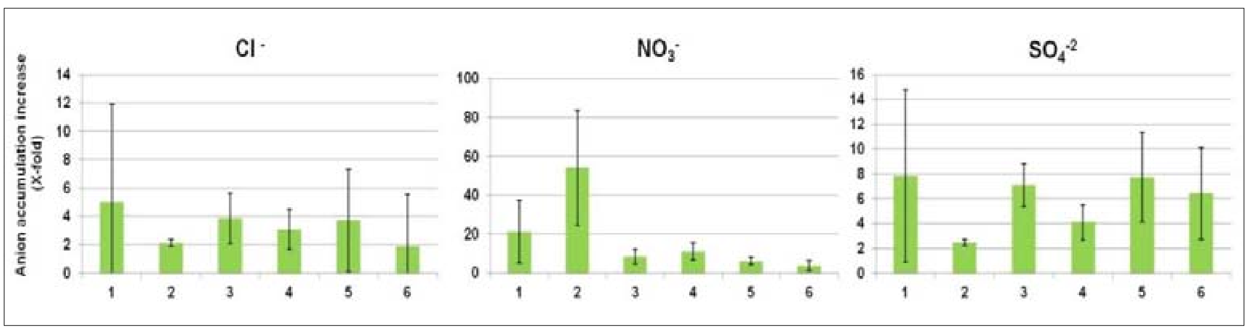
Background:

Irrigation management and nutrient mineralization are important aspects to consider in organic farming in order to optimize fertilisation management and consequently productivity. Those are also closely linked with a problem often observed in soils under organic production, soil salinization.

Project Overview:

The organic soils with different physical properties used were: 1) sandy soil, 2) peat soil amended with sawdust, 3) reconstituted organic soil with 40% air porosity, 4) sandy loam, 5) loam, and 6) muck soil. Ten grafted tomato plants (*Solanum lycopersicum*) were cultivated in each growing container from March 2010 to January 2011. The crop was fertilized using certified organic compost, crab meal and seaweed extract. Soil solution samples were collected weekly from suction lysimeters installed at a depth of 15 cm and ion contents was evaluated using an ion chromatography analyser ICS-1100 (Dionex Canada Ltd, Oakville, ON). A higher NO_3^- accumulation was observed in soil 2 compared to the others. The concentration of SO_4^{-2}, NO_3^- and Cl^- ions in the soil solution increased in all six soils throughout the production period. This overall increase in anions was associated with a decrease in biomass accumulation in tomato plants toward the end of the cropping season.



Conclusions:

Even though an accumulation in SO_4^{2-} and Cl^- in the soil solution was observed, no visual damages were noticeable on tomato plants. However, the increasing concentration in those anions might have resulted in the lower biomass accumulation observed towards the end of the experiment.

Acknowledgments: This research was funded by the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ) through the "Programme de soutien au développement de l'agriculture biologique".

The Use of Passive Bioreactors to Simultaneously Remove NO_3, SO_4 and Plant Pathogens from Organic Greenhouse Effluent.

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Background: Runoff of greenhouse nutrients creates environmental burdens such as eutrophication when the wastewater is not recycled. When the crop effluent is recycled, selective nutrient accumulation and consequently imbalances of ions such as sulfate (SO_4^{2-}) might lead to physiological plant disorder if the recycled nutrient solution is not partly replaced. Although recycling growing systems offer several advantages from an environmental standpoint, the risk of pathogen dissemination is also a major concern for growers. Passive bioreactors have been shown to be a low-cost biological alternative for treating agricultural or industrial wastewaters.

Project Overview: Therefore, the objective of this study was to evaluate the use of passive bioreactors to reduce the nutrient load (NO_3^- and SO_4^{2-}) and water-borne plant pathogens (*P. ultimum* and *F. oxysporum*) from greenhouse effluents. Sterilized and non-sterilized passive bioreactors (3 L) filled with a mixture of organic carbon material were used in 3 replicates. Prior the experimental period, bioreactors were saturated with sterilized Postgate B medium to promote the sulphate reducing bacteria. After a start-up period of 2-5 weeks, bioreactor units received during 15 weeks a reconstituted effluent including 500 mg L^{-1} SO_4^{2-} with or without 300 mg L^{-1} NO_3^-, and were inoculated 3 times with *P. ultimun* and *F. oxysporum* (10^6 CFU mL^{-1}). The efficacies to remove water-borne plant pathogens (99.9%) and nitrate (99%) were high for sterilized and non-sterilized bioreactors. During the first 6 weeks of water treatment, percentage of SO_4^{2-} removal was more important in non-sterilized bioreactors compared to sterilized bioreactors, indicating that SO_4^{2-} reduction was mainly due to its biological activity. In the absence of nitrate, percentage of SO_4^{2-} removal was high (86% to 91%) and drastically declined after NO_3^- addition. This NO_3^- effect can be explained by the fact that in anaerobic sediments, denitrification is the most energetically favorable form of respiration as sulfate-reduction yields less energy and hence tends to occur when NO_3^- is not available. The removal of SO_4^{2-} would thus be expected to occur sequentially after the depletion of NO_3^- as observed in the non-sterilized bioreactors at weeks 13 and 14 (3 to 4 weeks after NO_3^- addition).

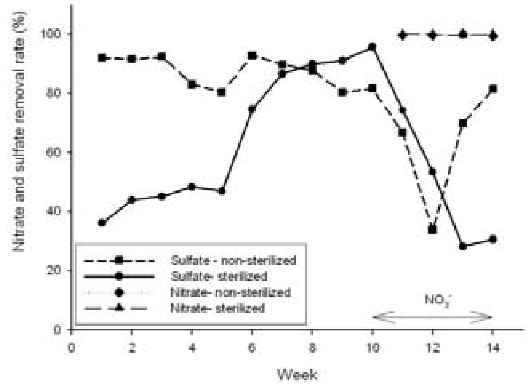

Figure 1 Evolution of the percentage of sulfate and nitrate removal of non-sterilized and sterilized bioreactors. Nitrate (300 mg L^{-1}) was added to affluent after week 9 until week 14. Date are means of n=3. Significant differences ($P<0.05$) were observed between the percentage of SO_4^{2-} removal of non-sterilized

Conclusions: This study shows that bioreactors are effective to treat greenhouse effluent. In the same times, bioreactors reduce sulfate, nitrate and water-borne plant pathogens.

Acknowledgments: This research was funded through Canada's Organic Science Cluster, which in turn was funded by the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and its industry partner, Les Serres Nouvelles Cultures. We are grateful to Claudine Ménard, Édith Tousignant and Réjean Bacon for their contribution to this project.

Cereal-Based Cropping Systems

Multi-criteria Analysis of the Glenlea Organic Rotation: The First 19 Years.

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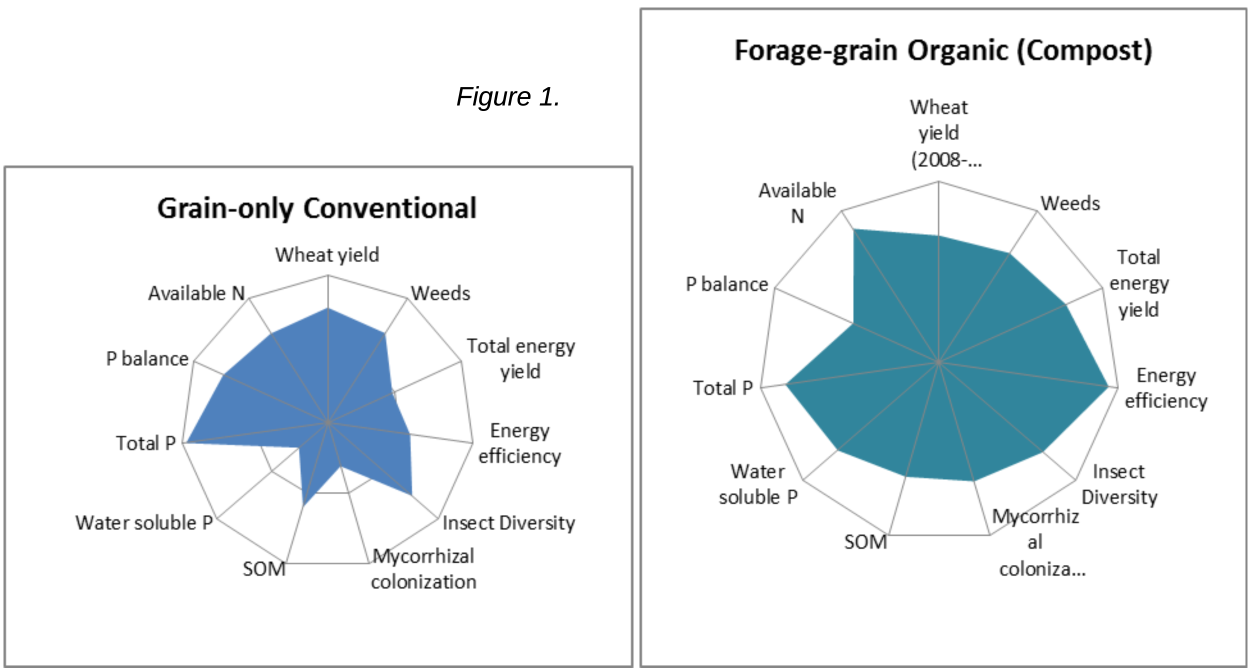
Background:
Sustainability is best determined when a broad range of relevant criteria are assessed simultaneously. This study compared organic and conventional production in two different crop rotations at Glenlea, and the study includes information collected between 2000 and 2010.

Project Overview:
A total of 11 criteria were measured and included agronomic performance (wheat yield, weed populations, and available nutrients); energy performance (energy production and efficiency); water quality risk (water soluable P); soil factors (soil organic matter); and biodiversity (AMF, insect diversity). Individual parameter responses are more positive when parameters are further from the centre (Figure 1). Results point out that each system/rotation combination has strengths and weaknesses (data not shown). However, when optimum organic and optimum conventional systems were compared (Figure 1), the optimum organic system outperformed the conventional system for most parameters.

Figure 1.



Conclusions:
In general, organic systems performed better for environmental and water quality parameters than conventional systems, but the reverse was true for crop yield. However, the highest overall performance was observed for the forage-grain rotation under organic management, provided that manure compost was added to the system.

Acknowledgments: Organic Science Cluster of Agriculture and Agrifood Canada; Manitoba government (numerous grants); Organic Agriculture Centre of Canada; NSERC.

Wheat Cultivar Development: Selection for Adaptation to Organic Production Systems.

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Background:
Organic wheat breeding is a relatively new endeavour for western Canada geared to identifying wheat genotypes with adaptation to organic growing conditions. Studies have provided evidence that conventional and organic production systems differ enough to warrant identification of cultivars with adaptation to the rigors of organic crop production. Canada Western Spring Wheat (CWRS) is the most widely grown type of wheat in the Prairies, about 74% of all wheat grown during 2010 and 2011. As a result, the restricted resources available for organic wheat breeding have been targeted to CWRS because of its market importance and breadth of use in prairie grain farming.

Project Overview:
Since 2004, a collaborative effort in Manitoba has been ongoing to create CWRS cultivars adapted for organic production. Approximately 20 F_2 populations are introduced into the organic breeding program each year from crosses made by the conventional CWRS breeding program located at the Cereal Research Centre (CRC) in Winnipeg. Material from F_2 to F_6 generations is selected for agronomic type and disease resistance in organic nurseries where natural infection from multiple diseases occurs followed by a first evaluation of yield at $F_{5:7}$. Six station-years of more extensive evaluation occur to detect candidates suitable for registration testing. Cooperation with peers in Saskatchewan and Alberta has allowed creation of a network of organic test sites that sample differing environments and provide sufficient information for candidate cultivar evaluation. Capacity to evaluate yield potential remains the greatest restriction to this work. Spring wheat organic programs cannot utilize contra-season nurseries because of phytosanitary rules for seed crossing international borders. But, linkages between the CRC conventional and organic programs offer opportunities for genetic gains in the conventional program to be transferred to the organic program. Cooperation with organic producers has been encouraged through the initiation of a participatory plant breeding program where selection within segregating F_3 and F_4 populations by producers at various locations provide opportunities for sampling environmental variation at early generations that conventional programs typically do not do.

Conclusions:
Experience from this work indicates all field experiments should be grown on green-manured land to manage weed, nutrient and moisture levels. Tolerance to weeds can be assessed in yield plots. Grain protein concentration is measured from F_3 generation onwards resulting in higher selection pressure for this important trait compared to conventional wheat programs. Similar agronomic, disease and end-use quality characteristics are selected for both conventional and organic breeding programs as the criteria for registration are the same. However, there are plant physiological features for response to nutrient stress, plant competition and interactions with soil microflora that are not understood and thus not currently available for use as selection tools. Yield performance remains the primary method to assess overall adaptation and performance in organic environments.

Acknowledgments: Funding sources including ARDI, CWB, WGRF and the Organic Cluster have funded this program and have provided training opportunities for two M.Sc. students.

Participatory Wheat Breeding on the Prairies.

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Background:
Participatory Plant Breeding is a dynamic collaboration between breeding institutions and farmers. The objective is to involve farmers in the breeding process and develop varieties that are locally adapted, accessible to farmers, and also to help maintain genetic diversity. Successful examples from around the world have produced varieties of crops ranging from field crops to fruits and vegetables. Previous studies have shown that due to the unique stresses found under organic management, a breeding program specifically for organic environments is recommended. A participatory approach to organic variety breeding may be particularly beneficial to organic farmers due to the heterogeneous nature of organic farms.

Project Overview:
In 2010, a Participatory Plant Breeding program for spring wheat (*Triticum aestivum* L.) was initiated by the University of Manitoba in collaboration with Agriculture and Agri-Food Canada (AAFC). The objective was to involve farmers in the wheat breeding process by providing early generation breeding material and have the farmers make selections on their own farm.

In 2011, the program expanded, due to media coverage, and included ten farmers and three farmer-based research stations. Participants were located in Manitoba and Saskatchewan. In the spring, participants were mailed three different populations of F3 seed to be seeded as 25 m^2 plots on their respective farms. Farmers were asked to seed, maintain, and harvest their plots, as well as make selections throughout the growing season. A manual was provided to the farmers giving suggestions on seeding, plot management, selection methods, and harvest methods. However, farmers were encouraged to draw on their own expertise and to adapt the suggestions to their own situation. Communication between the participants and the University of Manitoba was maintained by emails and phone calls.

Ultimately, the participants took different approaches to their plots. For example, some visited their plots regularly and actively eliminated poor plants, while others did not make selections throughout the season and chose to just harvest the plots.

The program will continue on-farm, with farmers once again maintaining their own plots by seeding the F4 and F5 populations. At the F6, the seed will be returned to the University of Manitoba and AAFC to be assessed in yield trials, with the goal of producing a registered variety.

Conclusions:
This participatory plant breeding program for spring wheat is still in its early stages and the potential registration of a variety will not be for another few years. However, the interest generated by the program indicates that farmers are interested in being involved in the breeding process. Some lessons learned from this experience include: The importance of spreading the word about the program through media, the benefit of producing the manual, and the importance of maintaining communication with participants throughout the season. Future collaborations between farmers and breeders can identify other crops that may benefit from a participatory breeding approach.

Acknowledgments: Thank you to the Canadian Wheat Board, the Western Grains Research Foundation, and Growing Forward for funding.

Using Mulches to Reduce Tillage in Organic Grain Production in Western Canada.

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Background:
In recent years, efforts have been invested in developing ways to reduce tillage on organic grain farms while maintaining good weed control (Vaisman et al. 2011). There has been a growing interest in trying to adapt the mulch production systems developed in the late 1980s by Brazilian no-till farmers (Bolliger et al. 2006) to Western Canadian organic grain production conditions. The objectives of the project were to determine the ability of different plant species to produce mulch and to measure the rate of decomposition of these various mulches. The ability for weed control of the mulches was also assessed, as well as the agronomic performances of the subsequent crop (spring wheat).

Project Overview:
A 2-year field study was conducted twice at the Carman Research Station in Carman, MB. In year 1 (Y1), the green manures (GM) were seeded in the spring and rolled in mid-summer, at the flowering stage. The GM species tested included barley, hairy vetch, pea, oilseed radish, and sunflower, in pure stand or in mixture. These rolled mulches were then left on the soil surface over the fall and the winter. In year 2, wheat was seeded directly into these mulches (no-till).

Hairy vetch established slowly in the spring (< 4 t ha^{-1} of aboveground biomass in mid-July Y1) compared to other GM species. However, hairy vetch was the only species that was not killed by the crimping action of the roller-crimper, and it kept growing until the end of October. Moreover, GM treatments with hairy vetch had the highest mulch biomass in September Y1 (9-11 t ha^{-1}), and in the spring Y2 (~7 t ha^{-1}).

The effect of GM treatments on weed biomass in the wheat crop in June Y2 was only marginally significant ($P = 0.08$). Wheat aboveground biomass at harvest was significantly higher in pure hairy vetch and in barley and hairy vetch mixture than in other treatments, in site A in 2011. Weed aboveground biomass at harvest was the lowest in pure hairy vetch and barley and hairy vetch treatments, in site A in 2011. Wheat will be seeded in site B in 2012.

Conclusions:
Continuous no-till in organic farming in Western Canada is definitely a challenge in terms of control of weeds and crop yield, although preliminary results from field experiments in 2010 and 2011 suggest that thick mulches (especially those including hairy vetch) have the ability to suppress weeds in mulch production system in Western Canada, thereby reducing the need for tillage. Concurrent research is monitoring decomposition of various mulches in litterbags for a period of 250 days. Other work considers the long-term agronomic performance of organic mulch production systems (no-till) compared to those of organic tilled systems.

Acknowledgments: Funding for this project was provided by the Canadian Wheat Board, the Government of Manitoba, and the Organic Science Cluster of Agriculture and AgriFood Canada. The first author is also grateful to NSERC and FRQNT for providing her with Ph.D. graduate scholarships.

Integration of Cultural and Mechanical Weed Control Strategies Enhance Weed Control in Organic Cropping Systems.

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Background:
Lack of effective weed control strategies have been one of the main constraints in getting higher grain yields in organic cropping systems. Effective weed management strategies are limited in organic cropping systems as herbicide use is prohibited. Weed control in organic cropping systems mainly rely on cultural and mechanical methods. However, the use of a single weed control strategy was not effective in managing weeds in organic systems. Therefore, enhancing the crop competitive ability by integrating both cultural and mechanical weed control methods could be a potential strategy in managing weeds in such instances. However, the relative efficacy of different cultural and mechanical strategies, their interactions, and additive effects when combined is not well known.

Project Overview:
The main objective of this study was to develop a competitive organic cereal cropping system integrating both cultural and mechanical weed control strategies. A study was carried out in two organically managed oat cropping systems in Saskatoon, SK, Canada in 2008 and 2009. Three cultural practices; crop genotypes, (CDC Baler-competitive) and (Ronald-less competitive), planting densities (250 plants m^{-2}-standard, 500 plants m^{-2}-high), row spacings (11.5cm-narrow, 23 cm-standard), and post-emergence weed harrowing were factorially applied in a randomised block design. Doubling the crop density from the standard increased the grain yield by 10.7 % and reduced weed biomass by 52 %. Competitive genotype reduced weed biomass by 22 % than non-competitive genotype. Post-emergence harrowing increased the grain yield by 13 % compared to the non-harrowed control. Moreover, harrowing reduced the weed density on three of the four site years tested. Despite individual effects, combining high crop density with post-emergence harrowing increased the grain yield up to 25 %. Furthermore, combined effect of high density, competitive genotype, and post-emergence harrowing decreased weed biomass by 71 % compared to the standard practices.

Conclusions:
Increasing the crop density was the most effective individual tactic in controlling weeds and obtaining greater yields. However, cultural and mechanical weed control practices when used alone were less effective in weed control in organic cropping systems. Greater weed suppression and enhanced grain yields can be obtained by integrating both cultural and mechanical weed management practices in organic cropping system.

Acknowledgments: The authors would like to thank Quaker Oats Company, North American Millers Association, Saskatchewan Oat Development Commission for funding this research project.

Potential of Various Amendments and Management Practices in Preventing Nutrient Deficiencies and Improving Yields for Sustainable Organic Crop Production.

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Background:
Soil fertility is one of the top three research priorities (weeds, nutrients, crop diversity/rotation) for sustainable organic crop production. Any nutrient limiting/not in balance in soil can cause drastic reduction in crop yield, produce quality, nutrient use efficiency (NUE), water use efficiency (WUE) and energy use efficiency (EUE), soil degradation/poor soil quality, nitrate leaching/water contamination and greenhouse gas (GHG) emissions. In the Canadian Prairies, maintaining adequate soil P concerns organic producers the most, because of inherently low available P in soil, P relatively insoluble and lack of suitable P amendments.

Project Overview:
A number of field experiments are underway to determine influence of management practices and amendments on crop yield, nutrient uptake, soil quality, nitrate accumulation in soil and GHG emissions. Management practices include: Crop diversification/rotation with deep taproot and shallow fibrous root crops, cop residue return, legumes for green manure, legumes for seed/forage in rotation and cereal - or oilseed - legume intercropping. Amendments used in our studies were: *Penicillium bilaiae*, AMF/MykePro inoculants, humates, rock phosphate (RP), rapid release elemental S (RRES), gypsum, composted manure, wood ash, alfalfa pellets, alfalfa-canola meal pellets, fish food additive, distiller grain, thin stillage and glycerol. In the alternative cropping systems study, crop yields (averaged over 12 years) were 30-40% lower in organic system than conventional system. But, lower input costs plus price premiums for organic produce normally resulted in favourable economic returns and energy efficiency. In the organic system, amount of P removed in crop exceeded that of P replaced, which can be a major yield limiting factor. The results also suggested that legume green manure or legumes in rotation can provide N, and composted manure can provide N and P lacking in the soil for organic crops. In experiments related to feasibility of amendments on certified organic farms, there was only small effect of RP and/or *Penicillium bilaiae* in increasing soil P level and crop yield, although finely-ground RP was more effective than granula RP in the third year after 3 annual applications. Other findings suggested the use of intercropping legume with cereal/oilseed crops, compost manure, alfalfa pellets, thin stillage, distiller grain, fish food additive, wood ash, gypsum, or RRES to improve crop yield by increasing nutrient availability.

Conclusions:
Sustainability of crop production and returns under organic farming can be increased by integrated use of management practices and amendments by preventing nutrient deficiencies. This may also improve soil quality and minimize environmental damage.

Acknowledgments: Thanks to Western Alfalfa, Saskatchewan ADF, Canada-Sask Green Plan, TOLKO Industries Ltd. and NOHFC/TBARA for financial assistance; International Compost Ltd. for supplying Rock Phosphate fertilizers; and AAFC, SARDA and TBARS staff for technical assistance.

Nitrogen Dynamics of various Organic Amendments on Cereal Crop Production within Organic Systems in Southern Ontario.

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Background:
Limited research exists to guide organic cereal producers using organic amendments as their major nitrogen (N) fertilizer. The research goal is to develop management recommendations for maximizing N input use-efficiency and recommend a standardized approach for monitoring N availability on organic farms.

Project Overview:
Cereal crops (winter wheat, barley, oats, winter spelt, and corn) were planted in the 2011 season on 8 organic farms in southern Ontario, Canada, on a range of soil types and N sources. The organic amendments included composted turkey litter, composted dairy manure, fresh broiler litter and an industrial bacterial by-product. They were applied, in a randomized complete block design, at rates ranging from 0% to 150% of the recommended N requirement for the specific crop. At 3 sites red clover which had been under-seeded and soil incorporated, was evaluated for its potential in-season N contribution to the cereal crop. At maturity, the crops were harvested for measurements of grain yield and grain N content. Soil test N was measured in samples taken prior to application of the organic amendment, and at post-harvest and mid-winter.

The residual N contribution of the amendments to the succeeding crop grain yields will be determined in the coming growing season. This will allow producers to make a more informed purchasing decision based on the N contributions in the two years after application. An N availability model will be constructed to evaluate best management strategies for ensuring that N release from these treatments is coordinated with crop N demand, and that N losses due to leaching and volatilization are minimized.

Conclusions:
Analysis of the last season's field work will be completed over winter and help to set the foundation for a second set of field experiments. Results from the field research will be presented at the conference and trends observed across all sites will be highlighted.

Acknowledgments: Thank you to OMAFRA New Directions initiative for providing the funding for this research. Special thanks to Organic Meadow for providing the network of willing and capable producers to work with. Lastly thank you to Cold Springs' (Maple Leaf Foods) generous donation of their organic amendment.

Cereal Cover Crops for Early Season Weed Control in Organic Field Beans.

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Background:
Cover crops can be a successful weed control tool in integrated farming systems. Research has shown that cover crops can reduce weed pressure either through direct competition for resources, by altering the soil surface conditions as a mulch or by reducing germination through the exudation of allelochemicals.

In the Midwestern United States, there has been substantial research on the use of fall rye cover crops in soybeans. However, there are few studies in Manitoba on cover crops or their use in pulse production. Organic field beans in particular stand to benefit since they are very poor competitors. The addition of a cover crop could also reduce tillage, which is the primary method of weed control.

Project Overview:
This study compares three cereal cover crops, fall rye (*Secale cereal* L.), barley (*Hordeum* vulgare L.) and oat (*Avena sativa* L.) to a no cover crop control for early season weed suppression in organic field beans (*Phaseolus vulgaris* L.). The objectives are to compare weed suppression by evaluating the physical effects of cover crops and their management on several microclimate parameters.

Cover crops were seeded in September, 2010 in 4 m x 8 m plots using 15 cm row spacing. Prior to seeding field beans in early June 2011, the main plot is split into tillage and no-till sub-plots. Navy bean (cv. 'Envoy') was seeded in 15 cm row spacing. Barley and oats are spring annuals and winter kill, offering an alternative to fall rye which requires active termination. Termination of fall rye no-till plots is done by mowing at fall rye anthesis 18 days after planting (DAP).

Preliminary results show that at pulse seeding, fall rye had reduced weed biomass (46 kg/ ha) compared to barley (117 kg/ha), oats (302 kg/ ha) and the control (329 kg/ ha). Mean light interception was highest in fall rye no-till plots (948 µmol s-1 m-1) 18 DAP. Also at pulse seeding, mean surface soil nitrate (0-15 cm) was lowest in fall rye plots (3.2 kg/ha). Plots that received tillage had higher soil nitrate (0-15 cm) 18 DAP and higher weed richness compared to no-till plots.

Conclusions:
Fall rye provided superior weed control, however early season competition for resources may have contributed to delayed pulse development. Tillage plots may have higher resource availability which is contributing to higher weed richness.

Acknowledgments: The Organic Science Cluster of Agriculture and AgriFood Canada and the Manitoba Pulse Growers Association.

Comparing Reduced Tillage Implements for Termination of Cover Crops.

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Background:

Intensive tillage practices have led to a decline in the productivity of agricultural soils worldwide. Traditionally, organic agriculture has widely relied on tillage for weed control and termination of cover crops. The potential to reduce reliance on tillage in Canadian organic cropping systems may be realized with new and existing mechanical methods for control of cover crops which include blade rolling, flail mowing and undercutting. These novel implements have been studied previously by other researchers with success.

Project Overview:

The objective of the current study is to conduct a direct comparison of the blade roller, flail mower and noble blade with standard tillage for termination of a pea-barley green manure cover crop as well as a fallow control. The experiment is being conducted at Carman, MB and Lethbridge, AB and is being repeated twice from 2010-2012. The green manure is planted and treatments are applied through termination method in year 1, followed by planting of spring wheat in year 2. The effect of termination method on surface residue, soil nitrogen, soil temperature, soil moisture, weed density and subsequent spring wheat production will be evaluated.

In early spring 2011, surface residue varied from 208-1556 kg/ha at Carman to 37-2605 kg/ha at Lethbridge with the lowest residue occurring in the fallow treatments and highest in the blade roll treatments at both sites. Excessively wet conditions in fall 2010 and spring 2011 combined with delayed seeding limited crop production at Carman. Total broadleaf weed density at stem elongation in spring wheat ranged from 115-307 plants/m^2. Therefore at Carman, the spring wheat was terminated with tillage and re-planted to buckwheat, which displayed a large treatment response to nitrogen. After 63 days of growth, buckwheat biomass ranged from 2678-7747 kg/ha, with the lowest biomass occurring in the flail mow and blade roll treatments and highest in the standard tillage and blade roll + tillage treatments. Following buckwheat (Carman) and spring wheat (Lethbridge) harvest, fall rye was planted with the goal of following the nitrogen dynamics into year 3 (2012).

Conclusions:

In year 2 at Carman, the blade roller and flail mower had higher surface residue, higher weed pressure and less available N than all other treatments. The noble blade provided intermediate effects on soil N and weed density relative to zero and full tillage treatments. Completion of the project in 2012 will enable us to provide technical and applied information on the impact of these implements to the entire cropping system and contribute to the advancement of low-till organic cropping systems.

Acknowledgments: Thank you to the Manitoba Pulse Grower's Association, the Natural Sciences and Engineering Research Council and the Organic Science Cluster of Agriculture and Agri-Food Canada.

Facilitating Organic Soybean Cultivation under Cool Temperate Climate Conditions.

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Background:

Soybean (*Glycine max*) may be a promising crop for organic cropping systems due to its ability to fix nitrogen from the atmosphere and because of its relatively high protein concentration as compared with other grain legumes such as field peas and faba beans. However, under climate conditions of Germany (comparable to the climate prevailing in some regions of Canada), the average crop heat unit during the growing season may be too low for most available cultivars. As a consequence, physiological maturity cannot generally be expected to be reached in each growing season by each cultivar. Due to soybean's relatively slow early canopy development many weed species may have a competitive advantage and soybean cultivation may require excessive weed management. Therefore, and because air and, consequently, soil temperature in early spring can also be very variable, the question arises if an early or a later date of sowing is preferable in order to promote early crop development less hampered by strong weed infestation. On sites where soybeans have never been cultivated before, treating seeds with *Bradyrhizobium japonicum* just before sowing is obligatory. There are several products on the market, however, there are still no experiences gained under organic field experimental conditions as to their efficacy, i.e. their effect on nodulation, crop growth and yield as compared with no seed treatment.

Project Overview:

Three experiments were set up and conducted in 2011 at the Hessische Staatsdomaene Frankenhausen (51.4 N; 9.4 E; 698 mm; 8.5°C mean), the organic (since 2001) research farm of the University of Kassel, Germany. Soil type of the experimental field (preceding crop: beet root) was a Haplic Luvisol; soil texture a silt loam. The field was ploughed in October 2010, and soil prepared with a rotary hoe (March, 28) and a finger weeder (April, 11) in order to reduce weed emergence after sowing. Just before sowing soybeans (65 germinable seeds/m^2) the experiments' land was prepared with a rotary hoe (April, 18).

Experiment 1 was a cultivar trial with 16 different soybean cultivars (different maturity groups) in four replications, experiment 2 a two-factorial trial with factor cultivar (cv. 'Aveline', cv. 'Gallec') and factor date of sowing (April 19, 26 and May 2). Experiment 3 was a two-factorial trial with factor 'cultivar' (1. cv. Merlin'; 2. cv. 'Protina'; 3. cv. 'Bohemians') and factor seed treatment (1. control; 2. Radicin No. 7; Force 48; HiStick; 5. Biodoz Rhizofilm). All experiments were conducted with four field replications. Amongst other parameters we assessed the date of emergence, phenological plant development, maturation, thousand-kernel weight, soybean yield at 91% dry matter and protein concentration (in % DM).

Soybean yield: Results of the first experimental season (2011) indicate the different yield potential of the cultivars tested. Average soybean yield of all 16 cultivars examined was 2.5 t/ha, highest yield (3.2 t/ha) was assessed for the Austrian cv. 'ES Mentor', lowest yield for the German cv. 'Petrina' (1.5 t/ha). In EXP2, date of sowing did not affect yield significantly, whereas yield differed considerably between cultivars (cv. 'Klaxon': 2.5 t/ha; cv. 'Gallec': 3.1 t/ha). In EXP3, soybean yield (mean of the 3 cultivars tested) decreased from 2.9 t/ha (Biodoz Rhizofilm), 2.7 t/ha (HiStick and Force48, respectively), 1.9 t/ha (Radicin 7) and 1.7 t/ha (control). These results show the importance of using seed treatment with *B. japonicum* and the relevance of the product chosen.

Acknowledgments: The financial support of the project by the Federal Office for Agriculture and Food is gratefully acknowledged.

Grain Yield, Yield Structure and Quality of Organic Winter Wheat as Affected by Row Width and Seeding Density.

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Background:

Winter wheat (*Triticum aestivum*) is an important crop plant for many organic farmers, both in Canada and Germany. The economic return of winter wheat with approved baking quality is usually higher than for other cereal crops. Under low-input or organic farming conditions optimum stand densities can generally be expected to be lower than in conventional farming systems. Moreover, with limited nitrogen availability wheat stand density finally may have a major impact on grain protein concentration and therefore the suitability of grains for bread production. Farmers are sometimes paid a surplus if the grains exceed a certain protein threshold. On the other hand, some traders reject wheat grain lots with a too low protein concentration. As a gramineous crop species stand density of wheat may respond strongly to the numbers of seeds sown by either increasing or limiting the number of tillers and - at later crop growth stages - the number of ears per area. At a given seeding density, the distance between individual rows chosen may further affect the above-mentioned agronomic parameters and finally grain yield and quality.

Project Overview:

We conducted a two-factorial field experiment in a randomized block design with three replications at the certified organic research farm of the University of Kassel (51.4 N; 9.4 E; 698 mm; 8.5°C mean) on a Haplic Luvisol derived from Loess over three successive seasons (2009-2011) in order to examine four different seeding densities (100, 200, 300, 400 seeds/m²) and five different row widths (37.5 - 28.1 - 18.8 - 12.5 - 37.5/12.5 cm) with three replications using cv. Achat, a high-protein baking wheat cultivar. Crop emergence tillers/m^2, ears/tiller, grains/ear and thousand kernel weight were assessed and the number of ears/m^2 was calculated from the former two parameters. Protein concentration in grain was calculated from nitrogen concentration determined according to the method by Dumas multiplied by 5.7. Results from three experimental seasons will be presented at the conference. For the parameters ears/m^2, grain yield (t/ha at 86% dry matter), 1000-kernel mass (g) and protein concentration, the year consistently had the most marked effect (Table).

	2009	2010	2011
1000-kernel mass [g]	39.2	44.2	54.8
Grain protein concentration [%]	9.87	9.04	10.90
	Grain yield [t/ha]		
Seeding density	2009	2010	2011
100	5.17	4.69	5.33
200	5.78	4.91	5.82
300	5.99	4.90	6.01
400	6.05	4.77	5.99
Seeding density	Grain protein concentration [%]		
100	10.07		
200	9.90		
300	9.92		
400	9.86		

Additionally, for the number ears/m^2 an interaction of both row width and seeding density with the year was established, while as a main factor only row width was significant. Only factor year had a statistically significant effect on 1000-kernel mass Grain yield responded to the seeding density, but response also depended on the year (2-fold interaction). Grain protein concentration was also affected by seeding density (Table).

Intercropping Barley and Pea for Agronomic and Economic Considerations.

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Background:
Intercropping refers to growing more than one crop in the same field at the same time; usually a mix of non-legume and legume crops. Intercropping can have many benefits, such as: Reduced input costs by lowering fertilizer and pesticide requirements; stability of crop production/economic returns due to diversity; convenience in harvesting of crop, especially pea; and efficient use of resources (e.g., nutrients – N fixation from legumes, water, light). Also, intercropping can lead to extra yield [called out-yielding (i.e., when yield produced by an intercrop is greater than yield produced by component crops grown in monoculture on same total land area)]. Out-yielding refers to Land Equivalency Ratio (LER), which was calculated from the ratios of seed yields of intercrops and sole crops by using formula [LER = (Intercrop1/Sole Crop1) + Intercrop2/Sole Crop2)]. There is little research information on the impact of intercropping non-legume and legume annual crops on yield, produce quality, economic returns and nutrient uptake/use efficiency in the Parkland region of Saskatchewan.

Project Overview:
A field experiment with barley-pea intercrop was conducted from 2009 to 2011 at Star City, Saskatchewan, to determine the feasibility of intercropping annual non-legume cereal (barley) and legume (pea) crops for optimizing seed yield and economic returns. Barley and pea were grown as monocrops and in intercrop combinations (alternate rows or same row), with application of N fertilizer at 0, 40 and 80 kg N ha^{-1} to monocrop barley and its combination with unfertilized pea. Average seed yield of barley-pea intercrop was greater compared to that of barley and pea as sole crops without applied N. Application of N fertilizer increased seed yield of barley but decreased seed yield of pea, resulting in only slight increase of seed yield of both crops together with applied N. Protein concentration in barley seed was highest when these crops were intercropped with pea without any applied N. Protein concentration in barley seed slightly decreased with N fertilization, but there was no effect of N fertilization on protein concentration in pea seed. The LER values for intercropping were usually much greater than 1, suggesting less land requirement for intercropping systems than sole crops for same seed yield. Net returns were lowest for barley as sole crop in all three crop price scenarios even with annual application of 80 kg N ha^{-1}. Net returns without applied N were only slightly lower in barley-pea intercrop than pea as sole crop. Net returns in barley-pea intercrop decreased only slightly with N fertilization.

Conclusions:
Intercropping barley with pea improved crop yield and net returns, and reduced land requirement compared to barley or pea as sole crops. Our findings suggest the potential of intercropping non-legume cereals with legume pea for improving seed yield and economic returns for organic crop production, most likely by minimizing crop N requirements (from external sources) through N fixation by legume.

Acknowledgments: Thanks to K. Strukoff for technical help.

Intercropping Canola and Pea for Agronomic and Economic Considerations.

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Background:

Intercropping refers to growing more than one crop in the same field at the same time, usually a mix of non-legume and legume crops. Intercropping can have many benefits, such as reducing input costs by lowering fertilizer and pesticide requirements; improving stability of production and/or economic returns by increasing crop diversity; convenience in harvesting, especially pea; and efficient use of resources (e.g., nutrients – N fixation from legumes, water, light). Intercropping can also lead to extra yield [called out-yielding (i.e., when yield produced by an intercrop is greater than yield produced by component crops grown in monoculture on same total land area)]. Out-yielding refers to Land Equivalency Ratio (LER), which was calculated from the ratios of seed yields of intercrops and sole crops by using formula [LER = (Intercrop1/Sole Crop1) + Intercrop2/Sole Crop2)]. There is very limited research information on the impact of intercropping non-legume and legume annual crops on yield, produce quality, economic returns and nutrient uptake/use efficiency in the Parkland region of Saskatchewan.

Project Overview:

A field experiment with canola-pea intercrop was conducted from 2009 to 2011 at Star City, Saskatchewan, to determine the potential of intercropping annual non-legume oilseed (canola) and legume (pea) crops for optimizing seed yield economic returns. Canola and pea were grown as monocrops and in intercrop combinations (in alternate rows or in same row), with application of N fertilizer at 0, 40 and 80 kg N ha^{-1} to monocrop canola and its combination with unfertilized pea. Average seed yield of canola-pea intercrop, when both crops were seeded in same row, was substantially greater than canola as sole crop without applied N. Application of N fertilizer increased seed yield of both canola and pea slightly in both intercrop combinations. Protein concentration in canola seed was highest when it was intercropped with pea without any applied N, and slightly decreased with N fertilization. Protein concentration in pea seed was greater in canola-pea intercrop than pea as sole crop, but there was no effect of N fertilization on protein concentration in pea seed. Compared to canola as sole crop, oil concentration in canola seed was lower in canola-pea intercrop, especially when no N was applied. The LER values were usually much greater than 1 for both intercrop combinations, suggesting less land requirement of intercropping systems than sole crops for same seed yield. Net returns were lowest for canola as sole crop in all three crop price scenarios even with annual application of 80 kg N ha^{-1}. Net returns without applied N were slightly greater in intercrop than pea as sole crop. In both intercrop combinations, net returns increased only slightly with N fertilization.

Conclusions:

Compared to canola and pea as sole crops, seed yield improved with canola-pea intercropping, especially when crops were grown in the same row. Our findings suggest the potential of intercropping non-legume oilseeds with legume pea for improving seed yield and economic returns in organic crop production, most likely by minimizing crop N requirement (from external sources) through N fixation by legume.

Acknowledgments: Thanks to K. Strukoff for technical help.

Reduced Tillage and its Impact on Canada Thistle (*Cirsium arvense*) and Grain Yield in a Cereal-Based Stockless Organic Crop Rotation.

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Background:

In organic farming permanent weed species such as Canada thistle (*Cirsium arvense*) may impose agronomic problems on the farmer, since they cannot be controlled by measures available to their conventional counterparts. Next to the cultivation of competitive cash crop species, perennial fodder crops may be a prospective strategy to counteract its proliferation. On stockless organic farms, and in cash-crop based organic farming systems, however, alternative strategies have to found.

Project Overview:

In the present field experiment, the following questions were asked: (i) Does reduced (RED) successive (4, 6-8, 10 cm) soil tillage with a skimmer plough have a higher degree of efficiency in terms of Canada thistle regulation than conventional (CON) stubble tillage with a cultivator (10-15 cm) followed by a plough (25 cm)? (ii) What is the impact of reduced soil tillage on grain yield and quality in a stockless cereal-based crop rotation? (iii) What is the benefit of a three year alfalfa-grass fodder crop when compared to three years of cereal cropping (RED or CON) with regard to cereal grain yield and Canada thistle in the fourth year? For this experiment we selected a field, managed organically since 1998 in 2007, which -then - was severely infested with Canada thistle. We set up a field trial with three factor levels comprising treatments RED and CON and a 3-yr alfalfa-grass ley (ALF), randomized in a block design with four replications. Initial infestation with Canada thistle was assessed for the first time just before harvest of a spring barley crop using Leica 500 GPS and the data were processed using Arc GIS 10 to obtain the % area infested with Canada thistle. The first differential stubble tillage (RED and CON) took place in summer 2007 after spring barley harvest. Subsequently, each year just before harvest of the grain crop (2008: winter wheat; 2009: triticale; 2010: Winter peas/triticale mixture; 2011: triticale) proliferation of Canada thistle and its density (assessed in reference plots) were assessed and grain yield as well as grain protein concentration measured. The results from four years (2008-2011) will be presented at the conference.

	2008		2009		2010			
	RED	CON	RED	CON	RED		CON	
	WW		TRI		WP	TRI	WP	TRI
Grain yield [t/ha]	3.5	4.2	3.3	3.5	2.7	0.9	2.9	1.2
1000-kernel mass [g]	48	49	44	43	105	33	104	31
Canada Thistle [Shoots/m^2]	43	60	34	34	19		27	
Increase in thistle area [%]	207	53	71	126	not estimated			

Table 1: Grain yield and 1000-kernel mass of winter wheat (WW), triticale (TRI) and winter peas (WP), Canada thistle shoots in reference plots and change (%) in plot area infested by Canada thistle as affected by either reduced (RED) or conventional CON) tillage (data from 2008 to 2010).

Only in one (2008) of three experimental seasons grain (winter wheat) yield was significantly lower when reduced tillage was applied, while 1000-kernel mass was not affected by tillage. Degree of Canada thistle proliferation was affected by tillage but there was an interaction with the year and could not be estimated in 2010 because winter pea triticale suppressed Canada thistle, so GPS measurements could not be done. While area occupied by Canada thistle increased, shoot density per area in reference plots decreased over the years.

Winter-hardy Grain Legumes: Suitability of Winter Pea (*Pisum sativum* L.) Genotypes for Cropping with Different Mixture Partners.

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Background:

Growing grain legumes may be favourable concerning e.g. fixation of airborne N_2 or disruption of disease cycles in crop rotations. However, spring pea (*Pisum sativum*) crop areas have been decreasing in the last years in many European countries due to their little resistance to lodging, high yield instability and often low economic competitiveness compared with other cash crops. Intercropping of peas with cereals or other crop species may reduce the weed problem and increase resistance to lodging. The yield stability of mixed pea/cereal stands is also known to be generally higher than in pure pea stands. Cropping winter peas may have several agronomic advantages over spring peas. In comparison to spring peas, winter peas have shown a higher yield potential and a higher yield stability. Winter peas have also been shown to have a higher N_2-fixation and a more pronounced preceding crop effect than spring peas in the rotation. However, until now, the overwintering of winter pea appears to be insecure under climate conditions affected by frequent incidences of frost in winter. Moreover, depending on growth patterns (semi-leafless, regular growth type) suitability for mixed cultivation with other crop species may vary. While triticale has become the standard mixture partner for winter peas, there is little information on the performance of canola and turnip when grown with winter peas.

Project Overview:

The experiment was set up and conducted in 2010-11 at the Hessische Staatsdomaene Frankenhausen (51.4 N; 9.4 E; 698 mm; 8.5°C mean), the organic (since 2001) research farm of Kassel University, Germany. Soil type of the experimental field (preceding crop: Oats after winter wheat) was a Haplic Luvisol, soil texture a silt loam. Data presented here (first experimental season 2010/11) were collected within a two-factorial field experiment in which we examined a collection of 17 winter pea genotypes (control: standard cultivar E.F.B. 33) and cultivated them in pure stands (80 seeds/m^2) and in mixture (40 pea seeds/m^2) with either triticale (*Triticosecale* Wittmack, cv. Benetto at 100 seeds/m^2), canola (*Brassica napus*, cv. Visby at 20 seeds/m^2) or turnip rape (*Brassica rapa*, cv. Largo at 40 seeds/m^2). The field was ploughed in August 2010 and - with a rotary hoe - prepared for sowing (September 22). We assessed crop emergence, over wintering rate ((number of plants/m^2 before divided by number of plants after winter) x 100), phenological development (BBCH system), crop and weed ground (%), thousand-kernel mass (g) as well as pea yield (t/ha) and grain protein concentration (% DM). Additionally we examined winter-hardiness in a frost-chamber experiment under controlled conditions. Overwintering and yield: On average of all 17 genotypes, an overwintering rate of 78 % was assessed ranging between 66 and 90 % as compared with the standard cultivar E.F.B. 33 (78%). Results indicate that there seems to be considerable variation in the genotypes tested regarding winter hardiness, but the following two experimental seasons still have to confirm if the observations are really due to genotypic differences in winter hardiness or if there are genotype x environment (year) interactions. The sowing date (September 22) was near the optimum for winter peas and for triticale, but probably too late for canola (data omitted from analysis), whereas turnip rape responded as less sensitive. Pea grain yield depended on mixture partner (turnip rape > pure stand > triticale), i.e. pea grain yield was higher when grown in mixture than when cultivated solely, while triticale somewhat suppressed peas, even at such a comparatively low seeding rate (100 grains/m^2).

Acknowledgments: The financial support of the project by the Federal Office for Agriculture and Food is gratefully acknowledged.

Fruit & Vegetable Field Crops

High Tunnel Production of Organic Strawberry: Effects of Fertilization Management on Three Cultivars.

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5. Agriculture and Agri-Food Canada, CRDH, St-Jean sur Richelieu, QC J3B 3E6.

Background:

High tunnel production is gaining in popularity in Eastern Canada to extend the harvesting season until October, increase yield, limit pathogen damage, and improve the quality of fruit and vegetables. However, very little research has been conducted to evaluate the season extension benefits and profitability offered by high tunnels for organic fruits. Actually, the fresh market for organic fruits is dominated by the United States in states such as California where ideal growing conditions occur during a long period of the year.

Project Overview:

Hence, the purpose of this study was to develop an organic growing system under high tunnels for day-neutral strawberry cultivars. To test the effect of fertilization and soil management on different cultivars, a split-plot experiment in four replicates was performed at Les Fraises de l'Île d'Orléans (St-Laurent d'Orléans, QC). Specifically, the effects of two fertilization regimes combined with two organic growing medium (main plots: 1- organic liquid fertilisation with an organic growing media; 2- organic solid and liquid fertilisation with an organic growing media; 3- conventional nutrient solution with an organic growing media; 4- conventional nutrient solution with a conventional growing media) and three cultivars (sub-plots; Seascape, Charlotte et Monterey) on soil mineral content, plant growth, yield and fruit quality were determined. Plants were transplanted in 3-liter containers, and watered with a drip irrigation system.

Conclusions:

Fertilization and growing media treatments had, in general, no significant effect on the total yield and fruit size. The harvesting period under high tunnels was extended by 4 weeks compared to the field crop. Under the organic and conventional regimes, the productivity of Seascape was 40% higher than Charlotte. Fruit dry matter of Charlotte was, however, lower under the organic regime compared to the conventional control. Results will also be discussed in term of nutrient availability as well as the profitability of this alternative growing system for organic strawberry.

Acknowledgments: This research was funded through Canada's Organic Science Cluster, which in turn was funded by the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and its industry partners, Les Fraises de l'île d'Orléans and Les Tourbières Berger.

Fertility Management of Establishing Organic Blackcurrants (*Ribes nigrum* L.).

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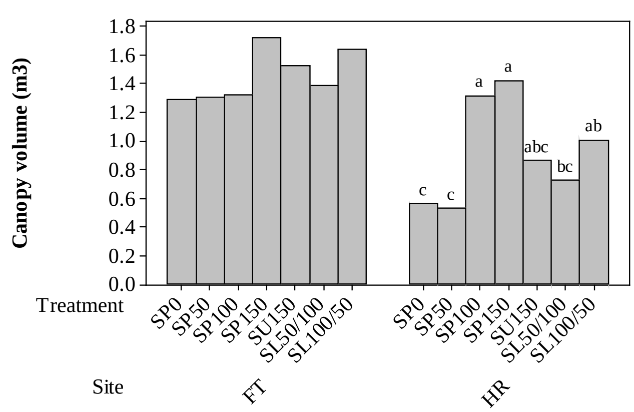
Background:

While Black currant (*Ribes nigrum* L.) production is prevalent in Europe and New Zealand, it has been slow to take off in North America. However, with increasingly resistant cultivars, a recent interest in organic production on Prince Edward Island has arisen to satisfy a health-savvy Japanese market that prizes blackcurrant berries for their high vitamin C, antioxidant levels and flavor. However, organic production of this fruit is extremely limited globally, and the growing conditions in Atlantic Canada are starkly different from other countries.

Project Overview:

Two sites of blackcurrant cv. “Titania” were established on PEI in 2009 to measure the effects of nutrient rate and timing on the growth, yield and nutrient uptake of establishing plants. Seven fertility treatments were used based on kg ha^{-1} of available N applied: control (SP0), three spring treatments (SP50, SP100 and SP150), one summer (SU150) and two treatments split across spring and summer (SL100/50 and SL50/100). The amendments were a mix of crab meal and poultry manure (Nutriwave™). Black plastic mulch was used to prevent weed growth. The two sites responded differently, with the FT having almost twice the yield of the HR site, and the treatments followed very different patterns. In 2011, there was no difference in bush volume or yield among amendment treatments at the FT site, unlike the HR site. Growth was highest for the SP150 at both sites, but the split treatments had higher yields. At HR, the growth rates of the summer-only and split treatments were much less than at FT. Tissue N was significantly higher in amended treatments than the control at both sites. Tissue tests revealed that K may be limiting at the HR site. No signs of nutrient deficiencies were noted at either site.



Canopy volume of black currant in response to soil amendments applied based on available N application rates in the spring (SP), summer (SU) or split spring and summer (SL).

Conclusions:

The best treatment for yield was SL100/50; SP50 and SU150 are not recommended, as the growth was much lower. Potassium may be limiting on one site.

Acknowledgments: Funding was provided through the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and Anne’s PEI Farm; in-kind support of participating farmers is also acknowledged.

Health Benefit and Horticultural Potential of Wild Blueberry Ecotypes of Northwestern Ontario.

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Background:
By combining plant science, horticulture, food science and social science this research aims to introduce commonly occurring but poorly studied wild blueberry species/varieties in northwestern Ontario to the Canadian horticulture and health food industry. We consider this research important because i) *Vaccinium angustifolium* Ait., *V. myrtilloides* Michx. and *V. angustifolium* var. *nigrum* occur commonly in northwestern Ontario but their relative distribution, yield and berry chemistry (specially antioxidant activity) are unknown, ii) in the Canadian blueberry industry, generally wild clones of lowbush blueberry (*V. angustifolium*) are cultivated and extensively studied, but the horticultural potential of velvetleaf blueberry and the *V. angustifolium* var *nigrum* variety of lowbush blueberry remained unexplored, iii) although freezing and drying effects on total anothcyanins, phenols and antioxidant activity of many commercially grown highbush blueberries and some lowbush blueberries are known, that of the velvet blueberry and the *V. angustifolium* var *nigrum* variety of lowbush blueberry are unknown. Many First Nations and other people in the North preserve these berries by freezing as well as sun and oven drying.

Project Overview:
Our research has five major objectives: 1) to determine the ratio of occurrence, morphology, berry yield and microclimate of *Vaccinium angustifolium*, *V. angustifolium* var. *nigrum* and *V. myrtilloides* in northwestern Ontario, 2) characterize the chemical attributes of the blueberries, in particular their antioxidant activity, 3) perform experimental field trials to compare growth, morphology, berry yield and quality of the blueberry types, 4) mass propagate clones with the best horticultural potential, and 5) examine the potential harvesting systems and marketing strategies for wild organic blueberries to stimulate new community based small business.

We have conducted extensive field surveys in 2010 and 2011 field seasons in 15 sites in NW Ontario. We have established an experimental field trial using split plot design near Thunder Bay with plants collected from nine sites.

Conclusions:
With respect to objectives 1-3, so far we have found that among the three wild species/varieties, *V. angustifolium* is the most common species with the highest yield and *V. angustifolium* var. *nigrum* is the least common variety with the lowest yield. We discovered that *V. angustifolium* var. *nigrum* flowers a week later and set fruits a week earlier than *V. angustifolium*. These findings have great importance for potential berry producers in northwestern Ontario, with the prospect of selling *V. angustifolium* var. *nigrum* berries in the market a week earlier than the common *V. angustifolium.* Research on blueberry antioxidant activity, organic market and community business potential are currently underway.

Management Strategies for Control of the Rosy Apple Aphid, *Dysaphis plantaginaea* (Passerini) (Homoptera: Aphididae) in Organic Apple Orchards in British Columbia.

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Background:
The rosy apple aphid *Dysaphis plantaginaea* (Passerini) (Homoptera: Aphididae) is an important economic pest in organic apple orchards worldwide. Aphid damage not only affects the current year's crop but also reduces the number of blossom clusters in the subsequent year. Consequently an economic loss is incurred in both years. Economic damage in high-density plantings of certain cultivars of apples e.g. 'Ambrosia', can reach up to $10,000 per acre over two years in a year with high aphid population density. Viable control methods for *D. plantaginaea* will have a significant positive impact on the livelihood of organic apple growers.

Project Overview:
This study had three main objectives. The first was to determine if oil sprays could be effective at reducing *D. plantaginaea* populations. Day length and a degree-day model were explored as tools to effectively time sprays. The second objective was to test if the removal of a major summer host of *D. plantaginaea,* broad leaf plantain, *Plantago major* (Lathrop) (Lamiales: Plantaginaceae) from orchards reduced aphid infestation the following year. The release of biological controls was also investigated as a method for reducing populations of *D. plantaginaea* in organic apple orchards.

Conclusions:
We currently have results from the first two years of data from the oil spray experiments. We have found that oil sprays in the fall applied between a day length of 12:05 and 11:15 and spring oil sprays applied between 170-258 degree days to be the most effective at reducing the mean percent of *D. plantaginaea* infested clusters per tree.

The mean percent of *D. plantaginaea* infested clusters per tree was significantly reduced following mechanical removal of *P. major* from orchard blocks. While results were statistically significant, the difference between control and treatment blocks is quite small. We will continue to remove plantain and will monitor these blocks in a high outbreak year to assess the efficacy of this method of control.

Early season releases of the biolocigal control agents *Aphidoletes Aphidimyza* (Rondani) (Diptera: Cecidomyiidae) and *Aphidius colemani* (Vierick) (Hymenoptera: Aphidiidae) did not reduce the mean percent of *D. plantaginaea* infested clusters per tree.

Acknowledgments: Thank you to the Organic Ambrosia growers (New Varieties Development Council) and the Growing Forward Agri-Innovations Program for providing funds. Thank you to Petro Canada for generously supplying us with oil for experiments. We also thank the organic apple growers in Cawston B.C. for providing test sites and assisting with trials.

Assessment of Carrot (*Daucus carota*) and Leek (*Allium porrum*) as Companion Organic Crops: Can they Benefit Each Other?

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Background:
In cropping systems, mixed cropping could provide better protection against insect or disease outbreaks. The ability of alliums to repel carrot rust fly is a characteristic that could benefit carrots in a companion cropping situation. The objective of this study was to determine the advantages associated with intercropping carrots and leeks, specifically on insect management and crop yield under South Western Quebec conditions. The effectiveness and cost of mechanical weed control were also evaluated.

Project Overview:
The three years study (initiated in 2010) was conducted on a Verchère muck soil at the Platform for Innovation in Organic Agriculture, St-Bruno de Montarville, Qc. The cropping treatments were carrots or leeks, either grown together as companion crops or monocropped. Three different weed treatments were applied under each cropping treatment: Physically weeded, manually weeded, or without weeding (weedy check). The following table summarizes some of the main results and conclusions of the first two year of the project:

Results	2010	2011
Pest insect of leeks	Leek moth population peak on august 9th - no damage reduction in companion plots	Leek moth population peak on august 18th – no damage reduction in companion plots
Pest insect of carrots	Low pest pressure, no damage reduction of carrot rust flies in companion plots	Very low pest pressure, no damage…
Marketable yield - carrot	No significant difference but slightly lower in companion crop	No difference between pure stand carrot and companion crop
Marketable yield - leek	Significantly lower in companion crop	No difference between pure stand leek and companion crop

Mechanical weed control was as efficient as manual control, by reducing the operation time in the companion plots by 75.7% in 2010 and 62.5% in 2011.

Conclusions:
Although the benefit of companion cropping against carrot rust fly damage could not be established, it was determined that physical weed control was just as efficient as manual weed control. In 2012, we should be able to confirm the best weed control system and possibly determine the benefit of companion cropping leeks and carrots against carrot rust fly damage and leek moth.

Acknowledgments: This study is part of the project: Agroecosystem management for pest control in organic vegetable production, financially support by the Organic Science Cluster.

Organic and Integrated Approaches to European Wireworm Control in Atlantic Canada.

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Background:

Significant losses in crop yield, quality, and marketability have been attributed to wireworms. Control of wireworms through the use of insecticides has proven difficult as most damage occurs after insecticides have lost effectiveness, and many are being deregistered. This has led to the need to develop alternative, integrated strategies that can be employed by both organic and conventional producers.

Project Overview:

Trials were initiated in 2008 to determine (i) crop preferences, (ii) effectiveness of organic deterrents, and (iii) the potential of soil-applied organic immobilization agents against wireworms (*Agriotes species*) in Nova Scotia. Crop preference trials investigated wheat, corn, red skinned potatoes, and dandelions relative to carrots. Organic deterrents such as marigold, brown mustard extracts and neem oil were tested by treating attractive baits with these deterrent agents in an effort to render the crop unattractive. Soil applied immobilization agents included diatomaceous earth, neem oil and wood ash to cause death or limit wireworm movement and/or feeding. Tests were carried out in plexi-glass chambers filled with a loamy sand soil at ~6% moisture. Wireworms were introduced to the chambers 24 hours after the baits/deterrents/ immobilizations were placed into the chambers, with the wireworm positions and incidence of feeding evaluated 24 hours later. Statistical analysis involved the 'G' test for independence for the crop preference and feeding deterrent trials, and an ANOVA for the immobilization experiment.

Results for the crop preference trial suggest that wireworms are more highly attracted to wheat than carrots (Fig. 1). Corn and dandelion did not differ in their attractiveness, while potato was less attractive than carrot. The marigold and mustard organic deterrents did not significantly alter wireworm feeding behaviour, whereas neem oil resulted in significantly fewer wireworms feeding, as well as fewer occupying the space in the chambers adjacent to neem treated baits. The presence of an immobilization agent did not affect wireworm movement in the soil, nor did they alter mortality or health over a two-month period.

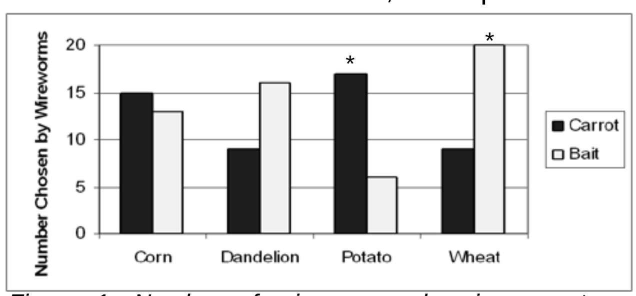

Figure 1: Number of wireworms choosing carrot or various baits (=significantly different from random choice, $p < 0.05$).*

Conclusions:

These trials have resulted in the identification of wheat seedlings as a promising bait crop in carrot production and neem oil as a potential feeding deterrent, however, a successful immobilization agent has not yet been identified. For more detailed information see our technical bulletins at: www.organicagcentre.ca/Extension.asp.

Acknowledgments: Thank you to Nova Scotia Department of Agriculture's Technology Development Program, the Province of Prince Edward Island, Bragg Lumber, Peter Swetnam (Dominion Produce), Horticulture Nova Scotia and Soil and Crop Improvement Association of Nova Scotia for their support and funding towards this project.

Canada's Organic Science Cluster, Activity D.1: Agroecosystem Management for Pest Control in Organic Vegetable Production.

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Background:
Few Canadian studies have examined the effectiveness of integrating the use of flowering strips, companion and trap plants and determined their impact on insect and weed populations in organic vegetable production systems.

Project Overview:
The purpose of this project is to investigate how organic vegetable production systems can be managed to increase biodiversity while preventing or minimizing pest problems. This project has been established at the Platform for Innovation in Organic Agriculture in Saint-Bruno-de-Montarville, Québec. It consists of 4 experiments repeated over 2 or 3 years. Crop production methods follow organic agriculture guidelines. Treatments were replicated four times in a complete block design. Each experiment has specific objectives. Experiment 1 was set up to determine the effect of crimper-rolled winter rye on weed control, insect populations and transplanted vegetable crop productivity. The transplanted crops are: A Brassicaceae (broccoli), a Solanaceae crop (pepper), an Alliaceae crop (onion), and a Cucurbitaceae crop (melon/squash).The four treatments are: Crimper-rolled rye, mechanical weeding; hand weeding, and no weeding. Experiment 2 was initiated to study the effect of companion planting of carrots with leeks on crop enemies (insects, weeds and diseases). The nine treatments are: Leek mechanically weeded, hand weeded and not weeded; carrot physically weeded (flaming and mechanical), hand weeded and not weeded; leek and carrot physically weeded, hand weeded and not weeded. Experiment 3 was undertaken to establish the efficacy of trap plants in attracting herbivorous insect populations while decreasing their incidence on the main crop. Yellow rocket and Jimsonweed are used as trap plants in cabbage and potato respectively to decrease the incidence of diamond-back moth and Colorado potato beetle, respectively. The treatments consist of two trap cropping arrangements and crops with no trap. Experiment 4 was carried out to determine the efficacy of different flowering strips in increasing insect biodiversity. The plants evaluated are: Alfalfa, petunia, phacelia, mustard, yarrow, alyssum, coriander, cosmos, French marigold, nasturtium.

Conclusions:
These experiments are ongoing and the results will be integrated in the use of flowering strips, companion and trap plants in organic vegetable production systems when they become available.

Acknowledgments: Thank you to Agriculture and Agri-food Canada (Organic Science cluster program).

Characterization of Berry Quality of *Ribes nigrum* in Relation to Harvest Timing and Cultivar.

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Background:

Consumers are constantly looking for new functional foods to incorporate into their diet. With that in mind, PEI farmers have started growing black currants (*Ribes nigrum* L.) to capture this market because studies have shown that black currants provide protection from certain cancers, cardiovascular diseases, type II diabetes, obesity, and age-related macular degeneration. These health benefits are provided by anthocyanins, a water-soluble pigment found in black currants. Black currants have never been grown commercially in PEI, so research on production practices and their effects on berry yield and quality is needed. Like most specialized fruit, growing organic black currants for large scale production requires specialized knowledge of factors that can affect berry quality. Understanding factors that can influence berry qualities like anthocyanins is important if growers intend to market their product as a functional food item. What are the most important factors affecting black currant berry quality?

Project Overview:

The specific objectives are to see how berry quality is affected by cultivar choice, harvest timing and site effect under PEI conditions. Berry qualities of interest are size, juice pH, titratable acidity (TA), total soluble solids (TSS) (measured as ^{o}Brix), total antioxidant capacity (TAC), total phenolic content (TPC) and anthocyanins (figure 1). Seven cultivars were established in a randomized block design including: Titania, Blackhome, Ben Alder, Ben Connan, Ben Sarek, Ben Tirran, and Whistler with two harvest timings, each replicated three times. The effect of harvest timing on berry quality characteristics of Titania was examined on two sites at four different harvest timings. Timing trials have been established on two sites with four harvest timings. Site effects are being measured on Titania growing on five separate farms.

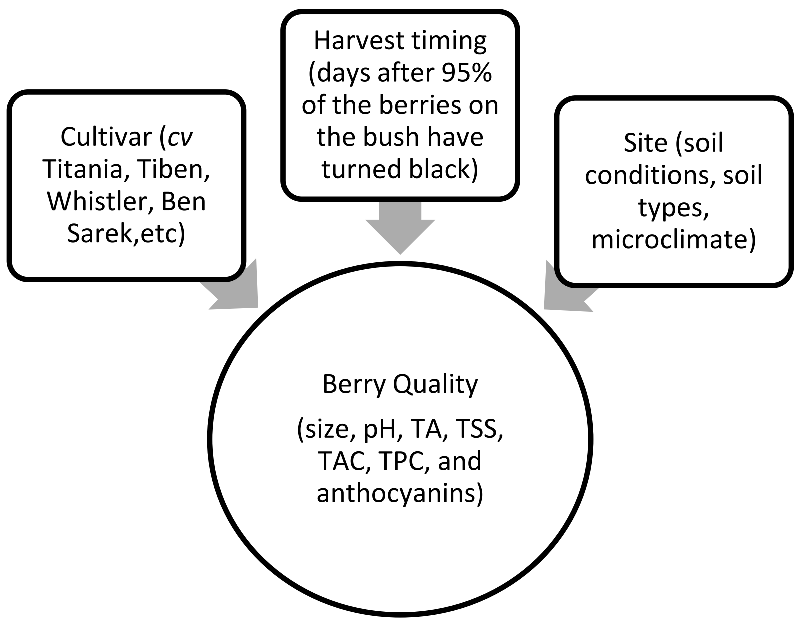

Figure 1. Factors affecting black currant quality

Conclusions:

Preliminary data analysis has indicated that there could be differences in the quality of berries harvested at different times and among different cultivars. These factors could be important in farmer cultivar selection and harvest management.

Acknowledgments: Funding for this research was provided by the PEI Agricultural Research Fund. Thanks to farmer co-operators Stephen Cousins, Mike and Frank Whitty, Ron Walsh, Mike Doucette, Raymond Loo, OACC and Tree Fruit Bio-product lab technical staff.

High Tunnel Production of Organic Raspberries.

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Background:

High tunnel production under Northern growing conditions can enhance the sustainability of organic berry fruit farming by the extension of the cropping season and the improvement of fruit quality. However, only marginal areas are organically-grown even though the market doesn't fulfill the demand for organic raspberry.

Project Overview:

The goals of this study were 1) to compare two organic fertilization management methods (liquid and liquid+solid) with a conventional culture grown under high tunnels and 2) to determine the effect of $CaCl_2$ spray foliar application on berry quality. A complete randomized experimental design with 8 replicates was established at Les Fraises de l'Île d'Orléans, QC, Canada and the combined 6 treatments were compared during 2010 and 2011. During the first growing season, no significant differences were observed in the soil nutrient solution, while soils of organic farming had higher content of N (28%), P (23%), K (46%), Mg (93%), Ca (17%), Fe (10%), Mn (17%) compared to conventional soil, resulting in higher nutrient leaf concentrations. At the end of the cropping season, higher (P<0.05) plant biomass (39-54%), yield (21%) and fruit size were observed under the organic production systems compared to the conventional system (P<0.01). Fruit quality was not affected (P<0.05) by $CaCl_2$ treatment. During the second growing season, similar results were observed with a net advantage for the organic farming.

Figure 1 The influence of three fertilization regimes on the total yield of raspberry grown under high tunnels expressed by g of fruit per linear meter (n=145).

Proc Mix
- Treatments P<0.01
- Month P<0.001
- Treatment*Month NS

Contrasts
- Conv vs Organic P<0.001
- L vs L+S* NS
- +Ca vs -Ca NS

*Liquid and solid organic fertilizers

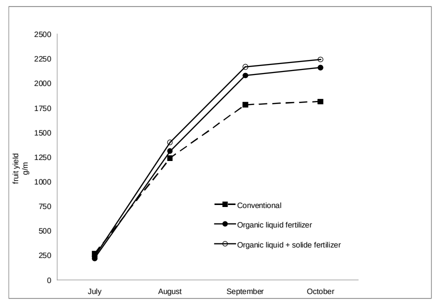

Table 1: Soil mineral content (Melich III) during the growing season 2010 (n=145).

Fertilization treatments	P (mg Kg^{-1})	K (mg Kg^{-1})	Ca (mg Kg^{-1})	Mg (mg Kg^{-1})	Fe (mg Kg^{-1})	Cu (mg Kg^{-1})	Mn (mg Kg^{-1})	Zn (mg Kg^{-1})	N tot (%)
Organic liquid fertilization									
July	168±3.01	305±13.69	1607±53.66	209±12.37	355±4.80	3.83±0.19	23±0.65	3.48±0.18	0,24±0.01
September	171±9.68	319±18.88	1472±61.22	180±7.76	308±8.38	4,14±0,19	17±0.60	2,86±0,15	0,21±0.01
October	183±12.54	339±16.26	1367±72.74	163±8.61	279±4.48	3.86±0.28	16±0.64	2.64±0.15	0,21±0.01
Organic liquid + solid fertilization									
July	158±3.26	275±9.48	1629±38.16	183±7.81	333±5.23	4.32±0.27	21±0.68	3,28±0.16	0,24±0.01
September	155±4.43	285±12.94	1514±61.33	167±8.86	308±5.58	4.66±0.24	16±0.46	2.96±0.14	0,22±0.01
October	162±7.33	306±14.19	1547±83.21	155±9.53	292±6.42	4,38±0.30	15±0.47	2,56±0.15	0,21±0.01
Conventional fertilization									
July	165±23.54	182±4.97	1311±37.24	81±2.03	309±4.15	4.19±0.21	18±0.38	1.49±0.06	0,17±0.00
September	113±2.29	216±11.91	1270±61.87	96±5.96	284±9.42	4.90±0.28	14±0.57	1.52±0.08	0,18±0.00
October	126±5.60	230±11.12	1336±53.37	97±4.11	261±4.94	4.62±0.26	14±0.61	1,27±0.08	0,17±0.003
P values									
Treatment	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	NS	P<0.001	P<0.001	P<0.001
month	P<0.05	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001
Treatment*month	NS	NS	P<0.01	P<0.001	P<0.05	NS	NS	P<0.01	P<0.05
Contrasts									
Conventional vs Organic	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	NS	P<0.001	P<0.001	P<0.001
Liquid vs Liquid+Solid*	NS	P<0.01	NS	NS	P<0.05	NS	P<0.01	NS	NS

* Organic liquid and solid fertilizers

Conclusions: Soils of organic farming had higher content of macro- and micronutrients resulting in higher plant biomass, yield and fruit size of organic-grown plants compared to conventional plants. No effect of $CaCl_2$ treatment on fruit quality was observed. High tunnels extended the cropping season by ~40 days under Northern growing conditions and are a promising way to produce high yield of quality fruits.

Acknowledgments: This research was funded through Canada's Organic Science Cluster, which in turn was funded by the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and its industry partner, Les Fraises de l'île d'Orléans.

One Step Towards Organic Seed Pumpkin Production in Québec: Evaluation of Three Varieties: 'Kakai', 'Snackjack' and 'Styriaca'.

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Background:
Seed pumpkin has been cultivated for many generations in Eastern Europe. Hulless pumpkin seeds offer an additional interest as they are easier to process and make oil extraction simpler. While consumers are concerned about food quality and nutritional value, the production of this type of pumpkin for snack and processing markets offers an interesting avenue for crop diversification on organic field crop farms and for additional revenue on small organic community supported farms (CSA).

Project Overview:
To evaluate the potential in Quebec of growing pumpkin varieties developed for seed production, a research project was implemented at the Platform for Innovation in Organic Agriculture. The main objectives of this study were to identify the best performing varieties of pumpkin for hulless seed production as well as the most appropriate and economical agricultural practices for organic growers. To reach these objectives, three varieties of pumpkin ('Kakai', 'Snackjack' and 'Styriaca') were grown under different practices: From seeds and from transplants, with and without insect netting against the striped cucumber beetle (*Acalymma vittatum*, SCB), the main insect pest of pumpkin. Seed yield and tolerance to SCB and to bacterial wilt (*Erwinia tracheiphila*, BW), a disease transmitted by SCB, were evaluated.

Our study showed that seeding these types of pumpkins gives very poor results. The use of insect netting allowed a good SCB control until flowering which is when the young plants are the most vulnerable to SCB attack. It also resulted in fruit and seed yield increase especially for 'Kakai' and 'Styriaca'. 'Styriaca' is the variety with the highest seed yield (2009: 802.3kg/ha, 2010: 912 kg/ha). However, this variety requires more days to maturity (135 days). This is an important feature to consider under our climatic conditions. 'Snackjack' produces the smallest fruit (ø: 10 to 13.5 cm;≤1 kg). This variety could be interesting to add to the baskets of CSA farms. This variety gave the following seed yield per hectare: 2009: 713.5 kg/ha, 2010: 585 kg/ha. 'Snackjack' has the advantage to require only 90 days to maturity. Also, this variety did not show to be attractive to SCB and had a very low mortality rate due to BW. 'Snackjack' was also the variety which performed the best at seeding very likely due to the presence of a very fine seedcoat. 'Kakai' was the variety the most affected by BW with mortality rate reaching up to 45% in 2009 and 2010. This resulted in seed yield losses which reached up to 500 kg/ha.

Conclusions:
Until practices to protect the hulless seeds from soil pathogens and insects are available, the use of transplants should be favoured to ensure a vigorous stand. Most of yields observed in our study were comparable to the ones reported from Eastern Europe which are between 500 and 800 kg per hectare (Bavec et al. 2007).

Acknowledgments: Thank you to the Conseil du développement en agriculture du Québec (CDAQ) (Défi-Solution program) and to the ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (INNOVBIO program) for the funding of this project.

Orchard Floor Management Affecting the Performance of Young Organic 'Honeycrisp' Apple Trees.

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Background:
In an establishing apple orchard, weeds can out-compete young trees for space, nutrients and moisture leading to a cumulative decrease in tree vigour and poor productivity. Herbicides are often used to control weeds but orchard floor management has the potential to successfully replace agrichemicals in weed control. Research on long term, non-chemical and sustainable solutions are needed.

Project Overview:
Six orchard floor management systems (OMSs) were installed in an establishing 'Honeycrisp' apple orchard aiming to suppress weed growth. Bare ground used as control, reflective mulch, reflective mulch placed over composted manure, composted manure, green manure and bent grass as companion plant cover were set up as replicated, randomized plots. The effect of these OMS on weed abundance, tree growth and leaf photosynthesis was assessed in 2011.

Weeds in each plot were identified and their percentage coverage was quantified. Compost plots had abundant weeds with 61 % and 87 % coverage respectively in June and July. Green manure plots had progressively more weeds as the season progressed, reaching 74% weed coverage in July. Bent grass and reflective mulch were most effective in weed suppression. Weed composition differed in the OSMs; chickweed was predominantly found in the compost plots whereas sheep sorrel was abundant in green manure plots.

By the end of the growing season, trunk diameter was measured in each treatment tree and the cross-sectional area (TCA) 30 cm above the scion-rootstock union was calculated. TCA was highest in trees treated with compost, followed by trees growing in the reflective mulch and bare ground plots; trees in the bent grass and green manure plots had the slowest growing trees. Leaf photosynthetic rate was highest in trees treated with compost.

This is the first cropping season for this 3-year old orchard. Although trees have not yet reached their full cropping potentials, those in compost plots and reflective mulch plots yielded on average 31 and 12 fruits respectively. Placing reflective mulch over compost had enhanced fruit yield with an average of 45 fruits produced per tree. Trees in bare ground, bent grass and green manure plots produced few fruits (0 – 4).

Conclusion:
Reflective mulch in combination with compost as an OMS is effective in weed control and promotes tree growth and fruit production. Research is ongoing to provide all apple growers with access to new management techniques and information for organic tree fruit production.

Acknowledgments: Research funds received from the Organic Science Cluster and the Technology Development 2000 Program are gratefully acknowledged.

Preliminary Observations on the Potential of Flowering Strips to Attract Beneficial Insects.

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Background:
It is now well recognized that the use of flowering strips may increase biodiversity as they provide a food source and habitat for beneficial insects. They also attract nectar-feeding insects, such as bumble bees, and hoverflies, which lay their eggs where there is an abundant supply of aphids for the larvae to feed on. Flowering plants have been shown to differ with regard to their attractiveness to parasitoids and nectar accessibility. This preliminary study aimed at determining the efficacy of flowering strips to increase insect diversity.

Project Overview:
The study was conducted at the Platform for Innovation in Organic Agriculture in Saint-Bruno-de-Montarville, Québec. The experimental design was a randomized complete block replicated 4 times. In 2010 and 2011, strips of single species were planted. Strip size was 2.4 m x 3 m. There were 40 strips in total (10 species x 4 replications). The plant species which were planted were: Alfalfa (*Medicago sativa*), petunia (*Petunia grandiflora* 'Ultra mix'), phacelia (*Phacelia tanacetifolia*), mustard (*Sinapsis alba*), yarrow (*Achillea millefolium* 'Colorado'.), alyssum (*Lobularia maritima* 'Easter white bonnet'), coriander (*Coriandrum sativum* 'Santo monogerm'), cosmos (*Cosmos bipinnatus* 'Sensation mix'), French marigold (*Tagetes patula* 'Bonanza mix') and nasturtium (*Tropaeolum majus* 'California giant'). Sweep net and yellow sticky traps were used to monitor insect biodiversity. Traps were changed weekly and insect nets were also swept weekly in each plot. Data collection included plant stage, density and biomass, and beneficial insects and pest abundance. In 2010, sweep nets sampling showed that petunia and alyssum presented the lowest number of predatory insects captured.

Conclusions:
The use of sticky traps gave a better description of the Coccinellidae abundance than the swept net technique. With the exception of alyssum, the most abundant lady beetle species was the multicolored Asian lady beetle (*Harmonia axyridis*) followed by the fourteen-spotted lady beetle (*Propylea quatuordecimpunctata*) and the spotted lady beetle (*Coleomegilla maculata*). Results from 2011 experimentation will also be presented.

Acknowledgments: Thank you to Agriculture and Agri-Food Canada (Organic Science Cluster program).

Weed Master: A Scale-appropriate Weeding Tool for Small Vegetable Farms.

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Background:
Hand weeding is the main method of weed control for small organic vegetable farms. Hand weeding and hoeing are costly and, in some area such as in Eastern Québec, there is insufficient labour available. Small-scale farmers need new tools that are scaled to the size of their operations and that can decrease the time required to manually remove weeds. Such tools should be versatile and can be used on a multitude of vegetable crops growing on small acreage.

Project Overview:
The Weed Master is a versatile manually-pushed tool carrier for seeding, flaming, and hoeing. It is designed to be used in vegetable fields that are up to 2 ha in area. Various weed control equipment can be attached on the same frame including: Disk hillers, finger weeders, sweeps and a flame weeder. The machine was imported in 2010 from Finland and was tested in lettuce (*Lactuca sativa*), cabbage (*Brassica oleracea*) and carrot (*Daucus carota*) for 2 years. The project was established at the Platform for Innovation in Organic Agriculture in Saint-Bruno-de-Montarville, Québec and Le Jardin Nature in Saint-Anaclet-de-Lessard, Québec. The objective was to determine Weed Master's efficacy against weeds and how it shortened hand weeding requirements. The experimental design was a randomized complete block design with four replications. The treatments were: Hand weeding, Weed master, Weed master + hand weeding, and weedy check. In 2010, the best treatment was a combination of Weed Master and hand weeding which improved yield and decreased the time required to hand remove weeds by 32, 32, and 58 % in lettuce, cabbage, and carrot, respectively. Results from the 2011 experiment will also be presented.

Conclusions:
Effective weed control on small vegetable farms is possible through the use of cultivation and flaming with the Weed Master. The use of the Weed Master can be economically viable because it is faster than hand weeding and provide similar yield.

Acknowledgments: Thank you to the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (INNOVBIO program).

Extension of Organic Research

Bringing Science Home to the Farm: Bridging the Gap Between Producers and Researchers.

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Background:
Located in south-central Saskatchewan, Upland Organics is a 1400 acre fully certified (COR, NOP, EEC) organic farm. Due to its location in the Wood Mountain Uplands, this farm contains a wide variety of soil types from sandy loam to clay. This farm produces a variety of crop types (cereals, pulses and oil seeds) employing a four-year crop rotation which includes a clover plow down. In addition to farming experience, each of the owner/operators of Upland Organics has a substantial background in either environmental science or mechanical engineering.

Project Overview:
A portion of the farmland currently in use was prairie newly broken within the last 2 years while the remainder of the land has been farmed for many decades. Due to the unique division between newly broken land and land with a clover plow down, we have been able to compare yields for flax (CDC Sorrel) between newly broken prairie and land that has been previously farmed. We found that on previously farmed land (using the four-year crop rotation including a plowdown) flax yielded 10 bushels/acre. On newly broken prairie, this same variety yielded 15 bushels/acre. This is a substantial increase in yield and we are interested in determining what methods can be used to increase the yields on previously farmed land.

Upland Organics is interested in being involved in several different areas of on-farm research including using new and emerging crop varieties, different crop rotations and different plow down crop varieties and methods. Currently we are experimenting with substituting a pea plowdown in place of our traditional yellow clover plowdown. We are also researching alternative methods for conducting this plowdown (mowing, disking, swathing) in order to best incorporate the nutrients from these plowdown crops into the soil.

Conclusions:
We feel that involving organic producers at the individual farm level will contribute to the overall applicability of organic research as it will allow for field testing and verification within the constraints of a working farm. With the combination of both a farming and scientific/technical background, we can offer a unique skill set beneficial to conducting a successful on-farm research program. Upland Organics is interested in furthering organic research through collaboration with research scientists, agriculture industry professionals and other organic producers.

An Organic Inspector's Dilemma: Responding to Questions on Production Standards Requirements and Sharing Relevant Research While Avoiding Consulting with Organic Operators.

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Organic standards in Canada require producers to "establish and maintain a fertile soil using practices that maintain or increase soil humus levels that supply an optimum balance and supply of nutrients and that stimulates biological activity within the soil." (Canadian General Standards Board) CGSB/CAN 32:310, Section 5.4 Soil Fertility and Crop Nutrient Management. Organic inspectors assess producers' compliance to this and all relevant standards while conducting the required annual on-site organic inspection of the operation. This assessment involves making many management system observations about the implementation and effects of their Organic System Plan and its annual update. Inspectors need to frame and pose questions to organic operators to assess the understanding that informs their production system problem solving and planning. This usually involves an exchange of questions, a conversation between operator and inspector, leading to references to specific standards, applicable in the situation under discussion.

The protocol requirements of the Canada Organic Office must meet ISO requirements, http://www.inspection.gc.ca/english/fssa/orgbio/man/orgbiomane.shtml which prohibit inspectors offering consultation to solve compliance issues during an inspection. However, inspectors often have access to research resources that may assist the operators in more fully understanding the application of the seven Organic Principles and Section # 5.4 of the Canadian Organic Standards (COS) in specific contexts. Extension services from organic specialists are available with wide access variations across Canada. The most frequent on-farm organic visitor often is the organic inspector. Assisting operators to understand the relevant COS required for their operations to meet standards is a responsibility of organic inspectors, yet this must be done without consulting. Methods to help producers understand the COS while respecting the limits of inspectors' responsibilities include having open discussions with growers to encourage the producer to propose solutions to problems. Meeting the ISO requirements does not mean inspectors have to be 'shut up, take notes, and report' inspectors. Organic inspectors must understand the potential impact of how they ask questions and what questions they ask!

Sharing publicly available references to research findings within the context of the on-site inspection can be very useful for producers' understanding of applying the organic standards. Examples of two recent discussion topics during field inspections include 1) mitigating flood impacts on soil quality, and reference to Dr. Yvonne Lawley's green manure work and the Manitoba Composting Association www.manitobacomposting.com and 2) options for more effective horticultural pest control and reference to Landing Theory.

Inspectors can meet their requirements as organic inspectors, maintain their Codes of Ethics and Conduct (#2. Inspectors support and encourage the development, implementation and advancement of organic agriculture and processing) and play an important role in organic extension, once they have answered where the inspection role starts and stops on the continuum of sharing extension resources.

Using a 12 Acre Organic "Mini-farm" for Extension and Education.

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Background:
To strengthen education in organic agriculture, we established a 12 acre organic "mini-farm" at the Ian N. Morrison research farm, Carman, MB in 2003. The mini-farm has been used for farmer, student and extension worker education and training.

Project Overview:
A 6-year crop rotation has been followed for the past 8 years: Oat/pea green manure-spring wheat-soybean-hairy vetch/barley green manure-flax-fall rye (or oats). Each field in the rotation is 2 acres, so commercial farm equipment can be used. Novel practices include: 1) use of a blade roller instead of tillage to terminate green manures; 2) no-till seeding of flax into hairy vetch/barley green manure and no-till seeding of fall rye into flax stubble; 3) chaff collection at grain harvest for weed and volunteer crop seed capture; 4) in-crop harrowing in wheat and soybean; 5) detailed soil analysis to monitor nutrient status; 6) calculation of rotation economics; and 7) pest monitoring. Rotation information and annual yields are available on our website (www.umanitoba.ca/outreach/naturalagriculture/articles/fieldlab.html).

The rotation is used for 3 main extension events: 1) The crop diagnostic school; a 2 week event where farmers and crop advisors visit the research farm for one day (400 visitors/yr); 2) the "Ecological and organic field day" held in July (80 visitors/yr); and 3) a University open house (150 visitors/yr). Smaller tours also occur. Responses from participants have been very positive. Diagnostic school students regularly rate the organic mini-farm at 3.5/4, similar to the best conventional extension components of the school. One participant in the 2011 organic tour wrote in his blog "Through the judicious use of plants that fix atmospheric nitrogen and return biomass to the soil, they have been able to achieve yields that come very close to the yields achieved by what is currently seen as conventional agriculture." The mini-farm allows graduate students to get hands-on experience with extension.



The mini-farm cost is $30,000 per year. We have been able to manage these costs since the mini-farm is an integral part of our overall organic crops research program.

Conclusions:
The mini-farm continues to be a unique place for learning about sustainable organic cropping systems, and allows for meaningful interaction between farmers and scientists.

Acknowledgments: Manitoba Agriculture, Food and Rural Initiatives, Manitoba Rural Adaptation Council, Manitoba Forage Council, Manitoba Pulse Growers Association, NSERC.

Social Science and Organic Agriculture

Innovation Shared is Resilience Built: Farmer-to-Farmer Learning and Adaptation To Climate Change.

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Background:
Adapting to variable weather patterns is an integral part of farming. Nevertheless, recent climate projections will require that farmers adapt to considerably greater change and variation than ever before. Recent research has shown that farmers in Canada have adapted to environmental change only when they have sufficient information and resources to do so. Farmer-to-farmer knowledge transfer has been well-documented as a successful method for transferring information, innovative practices and techniques. This research examines to what extent farmer-to-farmer learning facilitates farm-level adaptation to climate change.

Project Overview:
In collaboration with local farmers, I am currently testing how documenting and sharing local examples of effective adaptations using participatory digital media can assist with local adaptation strategies. Semi-structured video-interviews were conducted with 14 participants on 11 farms in the Pacific Northwest. The farmers were asked to discuss some of the ecological changes and challenges they were experiencing, and what innovative techniques and/or practices they were using to respond and adapt to these changes. Each farmer was video-taped demonstrating an innovative and practical technique to share with the greater agricultural community. These videos are currently being co-edited by me and the farmers to produce short 3-5 minute educational videos which will be uploaded to an information-sharing website. Feedback regarding the website as a video-mediated knowledge transfer tool will be sought from research participants, as well as an extension list-serve and other farm-related organizations.

Interviews revealed that direct impacts from unpredictable weather have resulted in crop loss, lower quality crops, and loss of growing capacity. All experienced farmers in the study perceived significant increase in precipitation, diseases (i.e. molds) and pests (i.e. slugs), and are all facing increasing difficulty with overwintering crops, and changes in seeding dates and times. All farmers noted the increasingly “truncated” season, due to the late on-set of spring conditions. All farmers cited “local community” as their most preferred information resource, and that they routinely conduct research using the internet. Additionally, all farmers expressed the desire for a substantial increase of “locally-relevant” information and resources, highlighting shortcomings of the current agricultural extension service, and most farmers gathered information from US-based internet sites.

Conclusions:
Though the small-scale farmers involved in this study are observing noticeable environmental change, they have limited economic capacity to adapt. Distribution of innovative, low-cost but locally relevant adaptations will require novel knowledge-sharing mechanisms. Online, farmer-to-farmer knowledge sharing through videos and photos may be such a mechanism.

Participatory Approaches to Organic Certification – Experiences from Mexico.

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The idea of providing consumers of organic products with some form of guarantee that what they are consuming is truly organic has been around since the early days of the organic movement. Until the 1990s, these guarantee systems tended to be self-regulatory, voluntary, and to rely on a process of peer review. However, as the organic sector has increased in scale, there has been a shift towards a third party model, in which standards and verification procedures are determined by independent agencies, certifications are carried out by professional inspectors and extension assistance is divorced from certification. While such a model offers a number of benefits, especially in terms of niche market access, it has been criticized for being inaccessible to small-scale, low income producers, and for its inability to capture some of the values commonly associated with the organic movement.

Currently, the most widely recognized alternative to third party certification is the participatory guarantee system (PGS) – a framework officially recognized by IFOAM that bears much in common with the early peer-review model. At a practical level, PGS seeks to make organic certification more accessible to small-scale producers, particularly those focused on local and regional markets. More broadly, it attempts to challenge some of the ideological assumptions that underlie third party certification – for example, the prioritization of export-oriented production, the notion that organic agriculture can be measured primarily in terms of prohibited and allowed inputs, and the idea that only formally trained experts can be trusted to make valid determinations of certification status.

Research on how PGS is being developed by a network of local organic markets in Mexico demonstrates that it offers a number of benefits for both producers and consumers. In particular, it allows producers lacking third party certification to legally market their goods as ‘organic’. At the same time however, there are a number of significant tensions inherent in the translation of the PGS perspective from theory into practice. The first is the delicate balance between maintaining space for grassroots decision-making and flexibility, while simultaneously creating the degree of standardization necessary to ease functioning and assure institutional recognition. This issue became particularly apparent during the drafting of a regulatory framework for the inclusion of PGS in Mexico’s organic legislation. A second challenge is the difficulty of trying to insert a system based primarily on trust into a market arena. Notably, consumers tended to exhibit relatively high levels of trust in local market producers regardless of certification status, whereas the producers themselves were sometimes less trusting of their colleagues. Finally, although progress has been made in recent years, there remains a gap between desired levels of active, broad-based participation in PGS, and the levels that have actually been achieved. This is especially so when it comes to engaging consumers in the PGS process.

Globalizing Organics: Trade Regulations and the Changing Meaning of Organic.

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Over the last decade, the rapidly increasing consumer demand for organic products in Canada and the U.S. has led to profound market growth in the organic food sector. In 2010, the size of North America's market for organic food products surpassed Europe's as the largest in the world. Today, retail sales of organic products are worth over $2 billion in Canada, and over $27 billion in the US, however, domestic production has struggled to keep up with demand. As a result, much of the certified organic food products consumed in Canada are sourced from abroad, particularly the United States. Organic products entering the global marketplace are now subject to the same global trade regulations as conventionally produced products. This paper assesses what the insertion of organics into the global trade regime has meant for the traditional social and environmental dimensions of organic agriculture, which includes sustainable labour practices and land stewardship.

This presentation looks at what happens when an alternate system of production is subject to the same rules and institutions as its conventional counterpart that it originally strived to replace. Though there are specific regulatory frameworks and quality standards for domestic organic production, organic food and agricultural products moving through the global trading system are subject to the same 'product based' regulations and food safety standards as conventionally produced goods. It examines organic food products in the context of the global trade agreements pertaining to food products and quality standards, namely the WTO's Sanitary and PhytoSanitary Measures (SPS) and the Technical Barriers to Trade (TBT) agreements as well as the concept of Process and Production Methods (PPMs) embedded in the TBT Agreement. This presentation discusses how the WTO's agreements have influenced the development of the organic industry and how these institutions are influencing what it means for a good to be organic. Substantive aspects traditionally associated with organic production such as farm size and crop rotation are exempt from consideration in the criteria for whether a food product is determined to be 'certified' organic, and this is fundamentally changing the dynamics of the organic sector.

The overall conclusion of the presentation is that the integration of organic foods into the global trading system has changed the meaning of organic. Ii has created a bifurcation of the sector, creating one segment that continues to focus on the substantive aspects of organic agriculture (process-oriented distinctions of organic) and the other, which focuses on capitalizing on the market expansion and the premium prices organic products garner (product-based production standards). It argues that with respect to retaining and reinforcing the substantive qualities of the traditional organic movement in 'certified' organic production, links must be further strengthened with social movements and networks of stakeholders committed to socially, economically and environmentally sustainable food production models.

Buying Local Organic Food: A Pathway to Transformative Learning

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Food is a powerful symbol in the struggle to transition to a more sustainable pathway since the food choices citizens make have deep environmental and social impacts within their communities, and around the world. Using transformative learning theory, this research explored the learning that took place amongst individual adults who consumed goods directly from local organic producers, and how this behaviour affected their worldview. Learning was classified as instrumental, communicative, or transformative. Ultimately, we considered if the learning created lasting change, directed toward a more sustainable society, amongst learners. Three different models of producer/consumer interfaces located in Atlantic Canada, were considered: A market-garden operation, an education and outreach centre, and a community shared agriculture project. It was found that all participants experienced some form of learning, either instrumental or communicative through their participation in organic agriculture. Closing the gap between producer and consumer through direct contact with the farmer at a market, visiting the farm, or participating in food production oneself is both a desirable step in reaching a more sustainable lifestyle, and a powerful learning tool in linking the consumer to a world of other environmental and social issues.

Science Cluster Strategic Meetings

The Science Cluster model is increasingly being used by AAFC for funding agricultural research of relevance to Canadians. The current Organic Science Cluster ends in March 2013. This full day of Organic Science Cluster Strategic Meetings will be used to discuss the priorities for research and formulate a strategic plan as we prepare the application for the next Organic Science Cluster for the period of April 2013 to March 2018.

The day will begin with an international panel of researchers, who have been invited to provide their perspectives in brief presentations.

Following the panel and discussion, breakout sessions will begin. Participants will be asked to break into sector-based groups to explore the following:

- What are the key barriers the sub-sector faces that can be addressed by research and innovation? Identify specific research questions that can address these barriers.

- What are the key opportunities the sub-sector faces that can be addressed by research and innovation? Identify specific research questions that can address these opportunities.

- What are the key threats the sub-sector faces that can be addressed by research and innovation? Identify specific research questions that can address these threats.

- Rate the economic impact, environmental impact, cost, likelihood of success and years to completion of each research question.

- What industry partners are most likely to fund this research?

The day will end with a wrap up session to identify strategic directions and priorities brought forward by the break-out groups.

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Organic Science Cluster Partners & Sponsors
This conference was organized as part of the Organic Science Cluster with funding from the following partners within the Organic Science Cluster:

Agriculture and Agri-Food Canada		Agriculture et Agroalimentaire Canada		Growing Forward a federal-provincial-territorial initiative
Canada	OFC FBC Organic Federation of Canada Fédération Biologique du Canada	University of Manitoba	NSAC. Embrace Your World.	Biologico Sainte-Sophie Saguenay
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