2021 Canadian Society of Soil Science Annual Meeting
BUILDING BRIDGES AND CONNECTING SOIL PROPERTIES

June 7-10th, 2021

Hosted virtually from Charlottetown,
Prince Edward Island
Canada

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Canadian Society of Soil Science
Société Canadienne de la Science du Sol

Thank you CSSS 2021 Sponsors!

Brookville Lime
AGLIME AND CRUSHED STONE

gasmet

HOSKIN SCIENTIFIC

ANONYMOUS
DONORS

Schedule Overview

Time	Monday June 7, 2021 - All times in Atlantic Daylight Time		
11:45 ADT	Welcome		
12:00-1:00	Keynote Speaker – Dr. Thea Whitman		
1:00-1:15	Break (15 minutes)		
1:15-3:20	Oral Sessions		
	Concurrent Session 1 Belowground biological responses to disturbances in soils	**Concurrent Session 2** Progress in predictive digital mapping and proximal soil sensing	**Concurrent Session 3** Soil science studies beyond conventional agricultural systems
3:20-4:10	Break	Viewing pre-recorded poster sessions 1-24 available on demand	
4:10-4:40	Concurrent sessions of Q & A for posters 1-24		
4:40-6:40	CSSS Annual General Meeting		
Time	**Tuesday June 8, 2021 - All times in Atlantic Daylight Time**		
12:00-2:05	Oral Sessions		
	Concurrent Session 1 Soil taxonomy and advances in pedology	**Concurrent Session 2** Nitrogen efficiency and environmental impacts	**Concurrent Session 3** Soil organic matter changes across ecosystems and time
2:05-3:00	Break	Viewing pre-recorded poster sessions 25-46 available on demand	
3:00-3:30	Concurrent sessions of Q & A for posters 25-46		
3:30-5:35	Oral Sessions		
	Concurrent Session 1 Soil science education in a COVID-19 world	**Concurrent Session 2** Promotion of soil health and water quality with sustainable agroecosystem management	**Concurrent Session 3** Soil-derived greenhouse gases: Measurements and mitigation I
5:35-5:45	Break (10 minutes)		
5:45	Soil Science Education Meeting	Graduate Student Trivia	
Time	**Wednesday June 9, 2021 - All times in Atlantic Daylight Time**		
12:00-1:00	Keynote Speaker – Prof. Raj Khosla		
1:00-1:10	Break (10 minutes)		
1:10-2:45	Oral Sessions		
	Concurrent Session 1 Biochar - its impact on soil and crop in Canadian agriculture	**Concurrent Session 2** Agroecology and soil health I	**Concurrent Session 3** Soil-derived greenhouse gases: Measurements and mitigation II
2:45-3:15	Break (30 minutes)		
3:15-4:50	Oral Sessions		
	Concurrent Session 1 The soil-water nexus	**Concurrent Session 2** Agroecology and soil health II	**Concurrent Session 3** Modelling carbon sequestration in Canadian landscapes to identify 'negative emission' opportunities to help realize Canada's emission reduction pledge
5:00	Student presentation awards & Judges meeting		
Time	**Thursday June 10, 2021 - All times in Atlantic Daylight Time**		
12:00-1:00	Keynote Speaker – Prof. Sieglinde Snapp		
1:00-1:15	Break (15 minutes)		
1:15-3:20	Oral Sessions		
	Concurrent Session 1 What long-term agricultural studies have taught us in terms of best management practices for soil health and crop production	**Concurrent Session 2** Connecting soil processes to 4R nutrient practices	
3:30	Awards ceremony & Wrap-up		

Oral Sessions

Monday June 7, 2021 - All times in Atlantic Daylight Time	
Time	**Welcome**
11:45 ADT	Opening address and instructions

Time	**Keynote Speaker**
12:00-1:00	Burning questions: Investigating the effects of fire on soil microbes **Dr. Thea Whitman**
1:00-1:15	Break (15 minutes)

Time	**Concurrent Session 1** Belowground biological responses to disturbances in soils	**Concurrent Session 2** Progress in predictive digital mapping and proximal soil sensing	**Concurrent Session 3** Soil science studies beyond conventional agricultural systems
1:15-1:20	Session introduction by chair	Session introduction by chair	Session introduction by chair
1:20-1:35	Multi-trophic diversity in soils across Prince Edward Island, Canada **Tandra Fraser**	Exploring the novel use of LiDAR-derived terrain information in soil mapping to support forest management **Babak Kasraei**	Ivermectin in cow dung affects soil microarthropods, microbial biomass and enzyme activity in grasslands **Newton Lupwayi**
1:35-1:50	Spreading the worm: invasive earthworms decrease soil carbon persistence in boreal forests **Justine Lejoly**	Building an enhanced provincial database of soil information and analytical data in BC: a call for collaboration and contribution **Jin Zhang**	Can the Denitrification-Decomposition model help with determination of optimal duration of grassland set-asides in Delta, BC? **Patricia Hanuszak**
1:50-2:05	Fungal dynamics, interactions, and contributions to the performance of Brassica napus **Navid Bazghaleh**	Useful terrain attributes for predictive soil mapping in the prairie landscapes of Saskatchewan **Jeremy Kiss**	Soil health dynamics following restoration of pipeline corridors on agricultural land **Clemence Muitire**
2:05-2:20	Soil bacterial, fungal and invertebrate biodiversity in an agroecosystem: a metabarcoding approach **Anibal Castillo**	Predictive soil mapping using historic bare soil composite imagery and legacy soil survey data **Preston Sorenson**	Cultivation of Switchgrass and Reed Canarygrass on a Soil Contaminated with Trace Metal Elements. **Léa Farrier**
2:20-2:35	Investigating the global drivers of earthworm species diversity on islands	cLHS-size: a technique to quickly determine minimum	Soil and vegetation properties following wellsite reclamation with suboptimal topsoil

	Jenacy Samways	sample size for the cLHS algorithm **Daniel Saurette**	replacement depth and organic amendments **Takudzwa Nawu**
2:35-2:50	Skid trails and landings can act as methane hotspots in a managed temperate forest **Juliana Vantellingen**	Developing soil property (soil organic carbon) map from the disaggregated map of the legacy soil maps of Middlesex County, ON **Tahmid Huq Easher**	Cleaning Up Heavy Metals Using Carbon Based Materials **Yihan Zhao**
2:50-3:05	The effects of chemical fumigation and biofumigation on soil N cycling, the abundance of soil N microorganisms, and the soil bacterial diversity **Louise Sennett**	Combining EMI measurements of electrical conductivity and magnetic susceptibility to better characterize soil drainage **Farzad Shirzaditabar**	Post-disturbance conifer tree-ring δ15N reflects openness of the nitrogen cycle across temperate coastal rainforests **J.M. Kranabetter**
3:05-3:20	Antibiotics and temperature interact to disrupt soil communities and their function **Jane Lucas**	Modeling total and active organic carbon dynamics using digital soil mapping **Paul Siddhartho**	The Effects of Decadal Climate Change on Recharge Rates in Semiarid Environments **Anne Paquette**
3:20-4:10	Break	Viewing pre-recorded poster sessions 1-24 available on demand (see Poster Sessions section)	
4:10-4:40	Concurrent sessions of Q & A for posters 1-24		
4:40-6:40	CSSS Annual General Meeting		

Tuesday June 8, 2021 - All times in Atlantic Daylight Time			
Time	**Concurrent Session 1** Soil taxonomy and advances in pedology	**Concurrent Session 2** Nitrogen efficiency and environmental impacts	**Concurrent Session 3** Soil organic matter changes across ecosystems and time
12:00-12:05	Session introduction by chair	Session introduction by chair	Session introduction by chair
12:05-12:20	Prairie Problems: When diagnostic features don't tell the whole story **Angela Bedard-Haugh**	Measurement-based tools to quantify soil nitrogen supply and verify right rate recommendations **Dave Burton**	Long-term shifts in litter deposition alters the molecular biogeochemistry of soil organic matter in temperate forests **Myrna Simpson**
12:20-12:35	Re-examination of drainage classes in coarse-textured nonhydromorphic soils **Jim Warren**	Use of low fertilizer 15N enrichment for quantifying nitrogen competition and fertilizer use efficiency in intercrops **Eric Bremer**	Clay type selects for distinct bacterial and fungal communities with consequences for soil organic matter chemistry and quantity **Cynthia Kallenbach**
12:35-12:50	Rationalizing gleying and mottling of Canadian soils **Richard Heck**	The Impact of Cover Cropping on Soil Nitrogen Availability, Nitrous Oxide Emissions, and Crop Nitrogen Use based on an Irrigated Prairie Cropping System **Olivia Otchere**	Orchards and vineyards as soil carbon 'hotspots' in the Okanagan Valley, BC **Kirsten Hannam**
12:50-1:05	Elevation of shallow soils within the taxa of the Canadian system of soil classification **Jim Warren**	Rye cover crop improves vegetable crop nitrogen use efficiency and yield in a short-season growing region **Sodeh Farzadfar**	Quantification of soil losses due to wind erosion in Montérégie-Ouest (Québec) **Andreas Felipe Silva Dimate**
1:05-1:20	Surface Organic Horizons for Chernozemic Soils Don't Get No Respect **Jim Miller**	Developing a CANB - Reactive N model to simulate nitrogen gas emissions and leaching losses in Canadian agricultural system **Jingyi Yang**	Distribution of Chernozemic great groups and carbon content across an elevation gradient of a semiarid grassland **Alex Kramer**
1:20-1:35	Better recognition of limnic materials and proposed modifications to the Organic Soil Order of the Canadian System of Soil Classification **Daniel Saurette**	Influence of soil aggregates on soil nitrogen mineralization and denitrification **Bangwei Zhang**	Restoring cultivated organic soils through organic amendments. **Jean Caron**
1:35-1:50	Proposed changes to the soil family taxa within the Canadian system of soil classification	Evaluation of seasonal dynamics of soil macro-nutrients and corn nutrient	Testing manganese limitations as the basis for enhanced forest soil carbon sequestration

	Jim Warren	uptake in fields amended with three types of municipal biosolids **Zheya Lin**	**Tim Philpott**
1:50-2:05	Southwest of Montreal organic soils: Pedology and characterization of physicochemical and hyrdodynamical properties **Raphaël Deragon**	Cancelled	Agriculture in the boreal forest: understanding the impact of land use change on soil organic carbon for developing sustainable community food systems **David Bysouth**
2:05-3:00	Break		Viewing pre-recorded poster sessions 25-46 available on demand (see Poster Sessions section)
3:00-3:30	Concurrent sessions of Q & A for posters 25-46		

Tuesday June 8, 2021 (afternoon) - All times in Atlantic Daylight Time

Time	**Concurrent Session 1** Soil science education in a COVID-19 world	**Concurrent Session 2** Promotion of soil health and water quality with sustainable agroecosystem management	**Concurrent Session 3** Soil-derived greenhouse gases: Measurements and mitigation I
3:30-3:35	Session introduction by chair	Session introduction by chair	Session introduction by chair
3:35-3:50	Alberta's Approach for Teaching Pedology Outside University Programs **Konstantin Dlusskiy**	Power of Soil: An Agenda for Change to Benefit Canada's Farmers and Climate Resilience **Paul Smith**	Mitigating nitrous oxide emissions from agricultural soils: an Irish perspective **Paul Murphy**
3:50-4:05	An On-line Oral Laboratory Final in Identification of Saskatchewan Plants and Soils **Tom Yates**	Phosphorus losses from Canadian agricultural land over three decades: Results from the updated Indicator of Risk of Water Contamination by Phosphorus (IROWC-P) **Keith Reid**	
4:05-4:20	Mobilizing soil science research knowledge with the SOILS AT GUELPH initiative **Cameron Ogilvie**	Critical phosphorus dilution curve and the phosphorus-nitrogen relationship in potato **Judith Nyiraneza**	Nitrogen functional gene abundance as potential indicators for nitrogen cycling under forage legume-grass pasture soils **Tram Thai**

4:20-4:35	3D Soil Monoliths for Virtual Classrooms **Lewis Fausak**	An 11-Year Agronomic, Economic, and Phosphorus Loss Potential Evaluation of Legacy Phosphorus Utilization in a Clay Loam Soil of the Lake Erie Basin **Tiequan Zhang**	Field scale soil freezing variability alters nitrogen cycling functional gene abundance and expression throughout freeze-thaw cycles **Lindsay Van Koppen**
4:35-4:50	Lessons Learned Teaching a Large Online Introductory Soil Science Course during the COVID-19 Pandemic: Instructor Perspectives **Sandra Brown**	Trade-offs in organic nutrient management strategies across mixed vegetable farms in southwest British Columbia **Amy Norgaard**	Tracking nitrous oxide production throughout a freeze-thaw cycle after fertilization with vs without a nitrification inhibitor **Trang Phan**
4:50-5:05	Teaching Assistant Perspectives on Student Engagement in Online Labs of an Introductory Soil Science Course **Joe Franco/ Crudo Lopez**	Precision Cattle Manure Management: Impacts on Surface Soil and Run-Off Water Quality **Deborah Ayanwale**	CH_4, CO and H_2 Inputs Trigger Community-level Physiological Responses in Soil **Anne de le Porte**
5:05-5:20		Effect of long-term rotation and cover crops on organic matter quality revealed by physical fractionation and soil health measurements. **Robin Bradley**	Quantifying greenhouse gas emissions from beef cattle grazed pastures sod-seeded with non-bloat legumes **Jiancan Liu**
5:20-5:35		Riparian zones: greenhouse gas emissions from the aquatic component **Maren Oelbermann**	Achieving greenhouse gas emissions reductions through precision manure management **Rich Farrell**
5:35-5:45	Break (10 minutes)		
5:45	Soil Science Education Meeting		Graduate Student Trivia

Wednesday June 9, 2021 - All times in Atlantic Daylight Time

Time	Keynote Speaker
12:00-1:00	Future of Farming: Big Data, Analytics and Precision Agriculture **Prof. Raj Khosla**
1:00-1:10	Break (10 minutes)

Time	**Concurrent Session 1** Biochar - its impact on soil and crop in Canadian agriculture	**Concurrent Session 2** Agroecology and soil health I	**Concurrent Session 3** Soil-derived greenhouse gases: Measurements and mitigation II
1:10-1:15	Session introduction by chair	Session introduction by chair	Session introduction by chair
1:15-1:30	Slow pyrolysis pine wood-derived biochar reduces nitrous oxide production from surface but not subsurface soil **Joann Whalen**	Predicting measures of soil health using the microbiome and supervised machine learning **Roland C. Wilhelm**	The role of riparian land-use systems in mitigating greenhouse gas emissions **Maren Oelbermann**
1:30-1:45	Hydrochar and liquid phase properties **Christopher Nzediegwu**	A soil health test for arable cropping systems in Saskatchewan Canada **Qianyi Wu**	Cultivating salix in agricultural-riparian transition areas to mitigate agriculturally derived N2O emissions from potato cropping systems on Prince Edward Island **Holly Wilts**
1:45-2:00	Capacity of biochar to adsorb Pb **Chinonso Ogbuagu**	Atlantic Canada Biodiversity Project: an early look at the free-living nematodes of New Brunswick, Canada **Erika Helen Young**	Comparing Greenhouse Gas Emissions from Agricultural Crops and In-Field Seasonal Wetlands **Waqar Ashiq**
2:00-2:15	Feeding biochar to beef cattle: nutrients & GHG **Carlos M. Romero**	Mixed row and alternate row intercropping of chickpea-flax and pea-mustard combinations to enhance yield and nutrient availability **Melanie Reid**	Effect of drainage system on soil greenhouse gas emissions from highbush blueberry fields in British Columbia **Paula Porto**
2:15-2:30	Biochar and manure and C mineralization **Tien Weber**	Effect of biobased residues on the soil physio-chemical properties of two temperate agricultural soils **E. A. Badewa**	Enhancing soil organic carbon storage through forested buffers and biochar application in agricultural lands **Cole Gross**
2:30-2:45	Shifts in nitrogen fractions in biosolids as affected by different treatment processes	Circular nutrient sources supply phosphorus and improve yields in organically managed systems	Assessment of a two timestamp vs. a four timestamp chamber sampling

	Qianhan Le	**Jessica Nicksy**	method for calculating soil greenhouse gas fluxes **Autumn Wiebe**
2:45-3:15	Break (30 minutes)		

Wednesday June 9, 2021 (afternoon) - All times in Atlantic Daylight Time			
Time	**Concurrent Session 1** The soil-water nexus	**Concurrent Session 2** Agroecology and soil health II	**Concurrent Session 3** Modelling carbon sequestration in Canadian landscapes to identify 'negative emission' opportunities to help realize Canada's emission reduction pledge
3:15-3:20	Session introduction by chair	Session introduction by chair	Session introduction by chair
3:20-3:35	Time to Ponding and Soil Sorptivity: An Historical Perspective with Climate-Change Implications **Gary Parkin**	Cover crops can, but do not necessarily, improve soil health in horticultural rotations **Carolyn B. Marshall**	Natural climate solution for Canada – Highlighting shelterbelts, agroforestry, wetlands and their potential to store carbon **Fardausi (Shathi) Akhter**
3:35-3:50		**Cancelled**	Soil carbon storage in prairie pothole wetlands **Chantel Chizen**
3:50-4:05	Enhancing soil drainage estimation by coupled soil and groundwater flow modeling **Yefang Jiang**	Using pea-based cover crop mixtures for nitrogen supply in Quebec organic grain crop production **Stéphanie Lavergne**	Accumulation and transport of pedogenic carbonates in wollastonite-amended agricultural soils: a microplot for long-term geochemical modeling verification **Reza Khalidy**
4:05-4:20	Characterizing carbon complexity across the land-water interface in agricultural landscapes **Lauren Weller**	Intercropping legumes in annual crops affect above and belowground biomass production and surface soil properties **Insaf Chida**	Stable soil carbon deficits beneath woody perennial crops of the Okanagan: a regional study **David Emde**
4:20-4:35	Deep soil water uptake of pinus banksiana in the Boreal Plain Ecozone of Saskatchewan **Eric Neil**	How do introduced non-bloat legumes impact carbon and nitrogen amounts and fractions in legume-grass pasture	Improving Ontario's modelling estimations of soil organic carbon sequestration in manure-amended croplands **Francis Durnin-Vermette**

		systems four years after sod-seeding? **Gazali Issah**	
4:35-4:50	Do overwinter plastic tarps provide better nutrient and water retention than cover crops? **Raelani Kesler**	Improved understanding of carbon dioxide net ecosystem exchange induced by crop diversification and the use of cover crops. **Jacob F. Evans**	Modelling soil carbon dynamics in annual and perennial agricultural systems using the Introductory Carbon Balance Model **Sarah J. Pogue**
5:00	Student presentation awards & Judges meeting		

Thursday June 10, 2021 - All times in Atlantic Daylight Time

Time	Keynote Speaker
12:00-1:00	Linking science to local knowledge systems: A soil science revolution **Prof. Sieglinde Snapp**
1:00-1:15	Break (15 minutes)

Time	**Concurrent Session 1** What long-term agricultural studies have taught us in terms of best management practices for soil health and crop production	**Concurrent Session 2** Connecting soil processes to 4R nutrient practices
1:15-1:20	Session introduction by chair	Session introduction by chair
1:20-1:35 1:35-1:50	The North American Project to Evaluate Soil Health Measurements **Cristine Morgan**	4R Practices for Nitrous Oxide Emission and Carbon Footprint Reduction of Crop Production **Claudia Wagner-Riddle**
1:50-2:05	Acidification from nitrogen fertilization has altered phosphorus forms and cycling in long-term wheat plots in Swift Current, Saskatchewan **Barbara Cade-Menun**	4R nitrogen management in the Canadian Greenhouse Gas Inventory **Doug Macdonald**
2:05-2:20	The Glenlea long-term rotation study **Sarah Wilcott**	Incorporation of 4R Practices in Greenhouse Gas Inventories **Stephen Ogle**
2:20-2:35	Effect on microbial networks in soils from short- and long-term applications of biosolids **Gordon Price**	Impact of nitrogen fertilizer rate on soil carbon and soil nitrogen: evidence from a 10-year trial in continuous corn **Joshua Nasielski**
2:35-2:50	90 years of agriculture on a Grey Luvisol: Management effects on soil health **Miles Dyck**	4R Management for Optimum Corn Yields and N Recovery Efficiencies Can Lower N2O Emissions **Tony Vyn**
2:50-3:05	Towards understanding soil health in Ontario Part I: Experimental design and land management data **Nicole Rabe**	The Effect of Freeze-Thaw Cycles on Nitrification Inhibitor Efficacy in Agricultural Soil **Konrad Krogstad**
3:05-3:20	Towards understanding soil health in Ontario Part II: Initial findings and future work **Christopher Blackford**	The Fertility of Canadian Agricultural Soils as a Metric of 4R Practice **Tom Bruulsema**
3:30	Awards ceremony & Wrap-up	

Poster Sessions

Monday June 7, 2021 - All times in Atlantic Daylight Time		
Time		
3:20-4:10	Break	Viewing pre-recorded poster sessions 1-24 available on demand
4:10-4:40	Concurrent sessions of Q & A for posters 1-24	

Poster	**Concurrent Session 1** Biodiversity & Soil health	**Concurrent Session 2** Pedology & Soil Science & soil mapping	**Concurrent Session 3** Agroecology
1 9 17	Biological control of root rot complex of field pea and lentil using bacterial isolates antagonistic to *Aphanomyces euteiches* **Ashebir Godebo**	Filling in the missing pieces: Using pedotransfer functions and machine learning techniques to augment British Columbia's soil data repository **Adrienne Arbor**	Developing a rapid infrared spectroscopic tool for assessment of novel lab-based soil health tests and identification of spectra patterns from Ontario soils **Andrew Hector**
2 10 18	Root influence soil microbial diversity and inter-kingdom interactions in different riparian land-use systems **Tolulope Mafa-Attoye**	Exploring the variability and dynamics of soil hydromorphism in riparian buffer systems using electromagnetic induction **Komathy Prapagar**	Soil health dynamics under an intermediate wheat grass perennial forage grain system **Nikisha Muhandiram**
3 11 19	The effects of terraces and tile drainage as best management practices on labile soil carbon fractions, greenhouse gas emissions **Bryan Driscoll**	Hierarchical Clustering of Soil Profile Horizons: A Tool for Data Analysis in Soil classification **José Carlos Lacayo**	Crop functional trait response to organic amendments and intercropping **Victoria Nimmo**
4 12 20	Aquatic dispersal of non-native earthworms in northern Canada **Stephen Paterson**	Mapping land suitability in areas with scarce ground data using Homosoils method **Qudratullah Rahmati**	Examining selected soil properties on the Lower Fraser River delta following four-year grassland set-aside **Teresa Porter**
5 13 22	Impacts of burn severity on fungal communities and soil carbon pools in dry Douglas-fir forests **Tim Philpott**	Effects of surfactants Tween-80 and Triton X-100 and colder temperatures on cow manure bioremediation of hydrocarbon-contaminated soil **Mano Krishnapillai**	Soil health and crop yields in four cropping systems transitioning to organic agriculture **Caroline Halde**

6 14 23	Tracking microbial gene abundances in soils over eight years of biosolids applications to agricultural soils **Gordon Price**	Rebuilding the Fertility and Productivity of Eroded Knoll Soils in South-Central Saskatchewan **Ryan Hangs**	Cover cropping influences on soil health, weed, and pest parameters, and carrot yield and quality under organic production **Francis J. Larney**
7 15 24	Carbon loss in surface runoff and tile drainage from a clay loam soil under 53 years of consistent agricultural management **Xueming Yang**	Comparison of agri-environmental phosphorus tests in boreal agricultural and natural Podzols **Amana Jemal Kedir**	Soil health in contrasting grazing and manure treatments in Manitoba. **Stephen Crittenden**
16		The influence of long-term agricultural management practices on the current status of soil physico-chemical properties of a boreal podzolic agricultural soil in Cormack, Newfoundland **Natalie Parsons**	

Tuesday June 8, 2021 - All times in Atlantic Daylight Time

Time		
2:05-3:00	Break	Viewing pre-recorded poster sessions 25-46 available on demand
3:00-3:30	Concurrent sessions of Q & A for posters 25-46	

Poster	Concurrent Session 1 Soil water and nitrogen use efficiency	Concurrent Session 2 GHG and carbon modelling	Concurrent Session 3 Soil organic matter
25 31 39	Using ^{15}N to identify spring wheat varieties and traits that improve nitrogen use efficiency **Iva Henry**	Topography controls N2O emissions differently during early and late corn growing season **Waqar Ashiq**	Response of cultivated organic soils respiration to straw and wood chips addition **Karoland Bourdon**
26 32 40	Nitrogen fertilizer replacement values of summer-seeded legumes for corn **Xueming Yang**	The biological sink of atmospheric H2 is more sensitive to spatial variation of microbial diversity than N2O and CO2 emissions **Xavier Baril**	Fine-tuning the methodology for measuring soil protein **Qianyi Wu**
27 33 41	Impact of land use intensity on soil nutrients and on enzymes involved in cycling of soil carbon (C), nitrogen (N) and phosphorus (P) **Yvonne Uwituze**	Fertilizer and tillage effects on soil nitrous oxide emissions from organic cropping systems **Joannie D'Amours**	Molecular-level characterization of alkali and acid extracted soil residues using Carbon Near Edge X-ray Absorption Fine Structure spectroscopy (NEXAFS) **Jeewan Gamage**
28 42	The different isotopic compositions in evaporating water and bulk soil water did not make a difference in estimated evaporative water loss **Wang HongXiu**	**Cancelled**	Efficacy comparison of common acid treatments used for carbonate removal from soils without affecting their organic carbon content **Nastaran Chalabianlou**
29 35 44	Soil pores; measuring the hole in the doughnut **Hida Manns**	How biosolids land application impacts N2O emissions and nitrogen use-efficiency in barley croplands? **Carmen Roman Perez**	Soil organic carbon content decreases partly attributed to dilution by increased depth of cultivation in southern Ontario **Adam Gillespie**
30 36 45	Soil degradation by land use in the semiarid region of Brazil	Exploring applicability of holos version 4.0 whole-farm	Species identity effect on soil C storage in European forests:

	Larissa Fernandes Costa	greenhouse gas (GHG) emissions model in canadian farms **Katie Barham**	broadleaves (oak, beech) versus a conifer (pine) **Richard Osei**
37 46		Evaluating the long-term effects of biobased residues on soil organic carbon dynamics using the Century Model **E.A. Badewa**	Monitoring soil organic carbon change in Saskatchewan farms from 1996 to 2018: Comparing on-farm management practices to long-term field experiments **Mervin St Luce**
38		Can increased crop yields from Canadian farmlands mitigate GHG emissions through soil C sequestration? **Arumugam Thiagarajan**	

Burning questions: Investigating the effects of fire on soil microbes

Dr. Thea Whitman, University of Wisconsin - Madison

Global fire regimes are changing, with shifts in wildfire duration, frequency, and severity predicted for North American forests over the next 100 years. Additionally, in many ecosystems, prescribed fires are an important management tool. Fires can result in dramatic changes to C stocks, through the combustion of biomass and organic soil horizons, as well as through the production of pyrogenic organic matter. In addition, fires can restructure plant and microbial communities within the ecosystem, which can have long-lasting effects on ecosystem functions. However, these effects depend on fire severity. We have investigated the effects of fire on soil microbial communities (bacteria and fungi), in prescribed fires in Wisconsin, as well as in an unprecedentedly extreme fire season in the boreal forest of Alberta and the Northwest Territories. Our approaches have included field surveys, laboratory experiments, and meta-analyses. I will address the following questions: (1) What factors structure soil microbial communities post-fire? (2) Which specific taxa respond positively to fires? (3) What ecological strategies allow bacteria and fungi to thrive post-fire?

Future of Farming: Big Data, Analytics and Precision Agriculture

Prof. Dr. Raj Khosla, Kansas State University

Precision Agriculture has been around for over two decades. The first decade had a strong focus on quantifying spatial variability in soils, the second decade spent significant time on science and technology of precision management of nutrients. Now, with increasing adoption of Precision management techniques and practices there is interest in harnessing the power of data to grapple the new paradigm of making management decision based on evidence. The success of future farming practices, output, efficiency and sustainability, would rely heavily on “farming the data” as much as “farming the land”. This presentation will empower the audience with research based information on how precision agriculture is embracing information and communication technologies and numerous aspects of big-data to transform agronomy and crop production systems. This presentation will include examples of where big-data has been pivotal in addressing agronomic challenges as well the greater role big-data can play in enhancing our understanding of variability in crops and soil properties as well as analyzing spatially dependent datasets to make highly accurate and timely agronomic decisions.

Linking science to local knowledge systems: A soil science revolution

Prof. Sieglinde Snapp, Michigan State University

Snapp's talk will discuss indicators of sustainable management and soil health, informed by participatory research with farmers, extension and policy makers from Michigan to Malawi, Southern Africa. Recent advances highlighted include the use of handheld sensors and big data to link science to local knowledge. A proof of concept is underway across Central Malawi cultivated lands where maps of soil carbon status are being updated based on linking local data to satellite data, to inform community and farm level management. Working with Malawi extension, targeted fertilizer and conservation practices have been provided to thousands of Malawi small scale producers. This evidence-based foundation supports local adaptation and actionable information on soil nutrient and organic matter status. For more information, check out http://globalchangescience.org/eastafricanode

Multi-trophic diversity in soils across Prince Edward Island, Canada

Tandra Fraser*[1], Hannah Arseneault[1,2], Derek Lynch[2], Lindsey Clairmont[1], Aaron Mills[1], Kyra Stiles[3], Judith Nyiraneza[1]

1. Charlottetown Research and Development Centre, Agriculture and Agri-Food Canada, Charlottetown, PE
2. Faculty of Agriculture, Dalhousie University, Truro, NS
3. Prince Edward Island Department of Agriculture, Charlottetown, PE, Canada

*Corresponding author: tandra.fraser@canada.ca

Interactions among soil biota and their environment exist at multiple trophic levels, with abundance, diversity and function essential for nutrient cycling and other ecosystem processes. Soil disturbance in intensively managed agriculture systems may disrupt the stability and resilience of these soil communities. Although declining soil organic matter (SOM) was reported in an 18 yr study of agricultural soils across PEI, with the lowest levels of SOM concentrated under high agricultural intensity (Nyiraneza et al. 2017), there is little information on the soil biology and functions in these soils. The objective of this study was to understand the effects of land use intensity (LUI) on soil biodiversity, focusing on nematode, protist (Cercozoan), and general eukaryotic communities and related soil functions. Field sites (n=60) were selected across PEI from the existing *Soil Quality Monitoring Project* (est. 1998) and grouped according to management as: 1) high intensity (2-3 yr rotation), 2) medium intensity (4 yr diversified), and 3) low intensity (undisturbed forest or grass). Five composite soil samples were collected per site and analysed for soil chemical, physical and biological parameters. Protist, nematode, earthworm and general eukaryotic communities were characterised using a combination of morphological and molecular (18S amplicon sequencing) techniques. The effects of LUI differed between the sites in 2018 and 2019. In 2018, LUI had a significant effect on all calculated indices (Chao, Ace, Jackknife and Shannon) for the Cercozoa and general Eukaryotic communities. In 2019, LUI only had an effect on the number of OTUs, Chao and Ace indices for both community analyses. The nematode communities showed more consistent results between years. The nematode communities in the low intensity system had higher maturity and structural indices than the medium and high intensity sites ($p < 0.05$), signifying a more structured community formed in the absence of tillage. Nematode communities from the high intensity sites had significantly higher basal indices compared to the low and medium intensity sites. Differences in nematode communities were more apparent at the family level than at the trophic level (e.g. bacterivores, fungivoures) and high abundances of Rhabditidae in the medium intensity soils contributed to higher enrichment index values, contrary to our initial hypothesis that this would increase with intensity. These results will be discussed in the context of 20 yr of soil chemical and crop rotation data, combined with soil health parameters from 2018 and 2019.

Spreading the worm: invasive earthworms decrease soil carbon persistence in boreal forests

Lejoly, Justine[1] (corresponding author: lejoly@ualberta.ca)
Quideau, Sylvie[1]
Laganière, Jérôme[2]
Martineau, Christine[2]
[1] Renewable Resources, University of Alberta, Edmonton, AB
[2] Laurentian Forestry Centre, Natural Resources Canada, Québec, QC

The Canadian boreal forest has been developing without earthworms since the last glaciation. Because of anthropogenic activities, earthworms are rapidly invading this biome. Unlike temperate forests, earthworm invasion in boreal forests remains understudied. Earthworms are known to decrease forest floor thickness. By incorporating litter into the mineral soil, they can also alter soil carbon stocks and carbon persistence. It is still poorly understood if these different mechanisms combined will result in a net carbon loss or gain for boreal soils.

The objectives of this study were to determine how invading earthworms could modify boreal soil: (1) morphological features, (2) total carbon stocks, (3) carbon persistence and (4) microbial communities. Study sites encompass the dominant soils found in boreal forests: Luvisols (Alberta), Brunisols and Podzols (Quebec). Carbon stocks were estimated for both the forest floor and surface mineral soil and carbon biological stability was assessed with a one-year laboratory incubation. Microbial communities were analyzed using both PLFA and DNA.

In most sites, the development of a darker top mineral horizon, classified as Ahu, was observed in earthworm-invaded soils and was associated with Vermimull humus forms. For Brunisols and Luvisols, forest floor carbon stocks were significantly lower in earthworm-invaded soils, mainly due to thinner forest floors. For Brunisols, a fraction of this carbon was transferred to the mineral soil, as mineral carbon stocks were significantly higher in the presence of earthworms, while those of Luvisols remained unchanged. This shows that the intensity of earthworm impacts varied amongst soil types. However, regardless of soil type, microbial community structure shifted following invasion, while similar microbial communities were observed in earthworm casts from different sites. In addition, the proportion of fast and active carbon was higher in the newly formed Ahu horizon. These findings suggest that invading earthworms are decreasing soil carbon stocks and/or persistence in Canadian boreal forests.

Fungal dynamics, interactions, and contributions to the performance of *Brassica napus*

Navid Bazghaleh[*1], Steven D. Mamet[1], Sally Vail[2], Steven D. Siciliano[1] and Bobbi Helgason[1]

1. University of Saskatchewan, Department of Soil Science, 51 Campus Drive, Saskatoon SK, Canada S7N 5A8
2. Agriculture and Agri-food Canada, 107 Science Pl, Saskatoon, SK S7N 5E2

   [*]Corresponding author: navid.bazghaleh@usask.ca

Abstract

The root-associated microbiome plays fundamental roles in plant nutrition, health, development, and resilience to biotic and abiotic stresses. Therefore, efforts in recent years have been focused on microbial phenotyping and breeding for desired community assemblies to harness the beneficial capacities of the microbiome to improve crop productivity. *Brassica napus* is an economically important and widely grown crop in the Canadian prairies, however the microbial diversity and composition for this plant species are yet to be established. In this study, we characterized the fungal microbiome in the roots and rhizosphere soils of sixteen diverse *B. napus* lines, and assessed factors determining their assembly in different environments in Saskatchewan based on the amplicon sequencing of the Internal Transcribed Spacer (ITS) region. We documented temporal, annual, site-related, and line-driven differences ($p<0.001$) in the root and rhizosphere fungal communities. Community composition and co-occurrence of key taxa showed dominant patterns and changes driven by environmental factors and niches. Habitat changes over the growing season shapes the associations between core taxa. The root-associated fungal microbiome of *B. napus* was overwhelmingly dominated by *Olpidium brassicae* comprising up to 81% of the root at two sites as well as abundant species from the genera *Fusarium*, *Fusicola*, *Gibberella*, *Mycosphaerella*, *Solicoccozyma*, and *Alternaria* and numerous less abundant species. The core microbiome was distinct for taxa observed in all site.years, however only a few of them were detected throughout the season, demonstrating the transient nature of even the most prevalent taxa. We further investigated the compositional structure of the root-associated fungi and their effects on plant performance. Our findings suggested a potential to optimize soil fungal contributions to agroecological performance in *B. napus* through plant breeding.

Soil Bacterial, Fungal and Invertebrate Biodiversity in an Agroecosystem: a Metabarcoding Approach

Anibal H. Castillo[1*], Robert Hanner[2], Kari E. Dunfield[1]

[1]School of Environmental Sciences, University of Guelph
[2]Department of Integrative Biology, University of Guelph
[*]acastill@uoguelph.ca

Soil holds a sizable portion of the Earth's biodiversity, yet most of it remains unexplored. A big outstanding question is whether below-ground biodiversity determines the biodiversity above-ground or vice versa. Both scenarios have been observed in different ecosystems, and the relationship may be bidirectional. Whether below-ground biodiversity is shaped by above-ground biodiversity in agricultural fields remains unknown, and the role of invertebrate diversity remains poorly understood. We hypothesized that soil microbial and invertebrate alpha (species richness) and beta (community composition) diversity would increase as plant diversity increases and will decrease with the presence of tillage. In this study, we assessed whether cover crop diversity or tillage impacted microbial and invertebrate species community composition within the first year of establishment of a long-term cover crop trial at the University of Guelph. The experiment was recently set up with a cover crop treatment consisting of 0, 1, 3, and 10 plant species and a split tillage treatment at two research stations. We evaluated significant differences in means between treatments for the alpha diversity metrics with the Kruskal-Wallis test. Differences in beta diversity were assessed with PERMANOVA using Bray-Curtis dissimilarity. We found no significant correlation in our study between an increasing gradient of above-ground plant diversity, represented by five different treatments, and the variance in a Principal Component Analysis (PCoA) of DNA diversity in microbial and invertebrate communities. There was a correlation between the variance in fungal communities and tillage in year 1. Besides, we found a site effect, as diversity at both levels is significantly different at both research stations. Our results show that while agricultural management, like crop diversity and tillage, can influence soil biodiversity, it might take several seasons to impact below-ground communities. We anticipate that this study will be a starting point to elucidate the long-term effect of agricultural practices on soil biota.

Investigating the global drivers of earthworm species diversity on islands

Jenacy Samways (Dept. of Environmental Science, Saint Mary's University), Dr. Helen Phillips (Dept. of Environmental Science, Saint Mary's University), and Dr. Erin Cameron (Dept. of Environmental Science, Saint Mary's University)
jenacyrae@hotmail.com

Large gaps exist in knowledge of the global patterns and drivers of biodiversity, particularly in belowground systems and island environments. Earthworms are a key group of soil invertebrates in many systems due to their ability to act as ecosystem engineers, yet our understanding of their distributions globally is limited. To investigate the drivers of earthworm species diversity on islands, I conducted literature searches to obtain lists of earthworm species on 379 islands. Earthworm species records were found for 99 of the searched islands, with many of the islands for which no species records were found consisting of entire archipelagos. The relationship between earthworm species richness and each island's underlying geology, latitude, distance from the mainland, temperature, precipitation, area, and plant species richness were analyzed using a zero-truncated negative binomial regression model. As predicted, earthworm species richness was positively correlated with island area and plant species richness, as well as mean annual precipitation, but negatively correlated with distance from the mainland. Less expected was a strong correlation to oceanic island geology and a relatively low occurrence of globally widespread species such as *Lumbricus terrestris*. However, it is clear that earthworm species data on a great number of islands is severely lacking. Future research should also investigate whether drivers differ for the diversity of native versus non-native species of earthworms on islands.

[Note: this is a general soil biodiversity talk which didn't fit clearly in any category, so I selected "belowground biological responses to disturbance in soils" as it seemed to be the closest.]

Skid trails and landings can act as methane hotspots in a managed temperate forest

Juliana Vantellingen[1], Sean C. Thomas[1]

[1] Institute of Forestry and Conservation, John H. Daniels Faculty of Architecture, Landscape and Design, University of Toronto, 33 Willcocks St. Toronto, ON, M5S 3B3, Canada.

Temperate forests soils generally act as a significant methane (CH_4) sink, however disturbances to the soil condition can cause a shift to CH_4 emissions. Forest management actions such as the creation and use of skid trails and landings cause significant alterations to soil moisture dynamics, porosities, and the amount of incorporated organic matter, all of which could cause shifts in soil CH_4 flux dynamics. To date studies have found reduced CH_4 consumption in experimentally created skid trails, and a study in Brazil has recorded strong emissions from landings. No similar studies have been conducted in North America and from real harvest areas that would experience a large amount of vehicle traffic. We quantified soil CH_4 flux rates from skid trails and landings in a managed forest in central Ontario and investigated edaphic drivers of the recorded fluxes. We found that in general CH_4 consumption was reduced on skid trails and landings; however, highly trafficked trails and some zones of landings were strong CH_4 sources. Drivers of CH_4 emissions differed between the skid trails and landings; skid trail emissions were correlated with low soil porosity and high soil moisture content, while emissions on landings were correlated with increased soil pH, organic matter content, and quantities of buried woody debris. Scaling up, skid trails offset ~45% of the surrounding soils within the harvest area, while landings were estimated to offset ~11% despite making up a very small portion of the managed forest area. This reduction in CH_4 consumption has been previously overlooked in greenhouse gas budgets of managed forests and will be crucial for future carbon credit scheme development.

The Effects of Chemical Fumigation and Biofumigation on Soil N Cycling, the Abundance of Soil N Microorganisms, and the Soil Bacterial Diversity

Louise Sennett[1,2*], David L. Burton[1], Claudia Goyer[2], and Bernie J. Zebarth[2]

[1]Department of Plant, Food, and Environmental Sciences, Dalhousie University, Truro, NS, Canada
[2]Fredericton Research and Development Centre, Agriculture and Agri-Food Canada, Fredericton, NB, Canada

Chemical fumigation and biofumigation are used to reduce soil-borne diseases; however, non-targeted microorganisms involved in essential soil processes, such as the soil nitrogen (N) cycle, may also be affected. This study compared biofumigation and chemical fumigation for their effects on 1) key soil N processes, 2) soil bacterial diversity, and 3) the abundance of key N-related microorganisms. Six treatments were examined: chemical fumigation with either chloropicrin, or metam sodium (MS), a combination of MS plus barley plant residues, biofumigation with mustard plant residues, barley plant residues, and an untreated control. Soil microcosms were incubated for 160 days under controlled conditions. The mustard residues did not inhibit soil nitrification, whereas chemical fumigation with MS (with and without barley) and chloropicrin inhibited soil nitrification for 16 and 64 days, respectively. Only treatments with organic carbon addition (mustard residues, barley residues, and MS+Barley) significantly increased CO_2, N_2O, and denitrification emission rates. Chemical fumigation with chloropicrin, MS, and MS+Barley significantly decreased nitrifier gene abundance compared to the mustard residues. Chloropicrin was the only treatment that reduced the abundance of several denitrifying genes. The mustard residues significantly reduced the Shannon-Weaver, Chao1 richness, and Pielou's evenness diversity indices at early time-points, whereas chloropicrin reduced all three diversity indices at the end of the incubation. In contrast, MS and MS+Barley did not affect the diversity indices throughout the entire incubation. After 160 days, the bacterial beta-diversity of all the treatments was significantly different from the control, with chloropicrin exhibiting the greatest change in bacterial community composition. These results suggest chemical fumigation, especially with chloropicrin, had a greater impact on nitrification, nitrifier and denitrifier gene abundance, and the bacterial community compared to biofumigation.

Antibiotics and temperature interact to disrupt soil communities and their function

Jane M. Lucas[1], Bronte Sone[1], Dana Whitmore[1], Michael S. Strickland[1]

[1]University of Idaho, Department of Soil and Water Systems, 875 Perimeter Drive, Moscow, ID 83844

Corresponding Author:
Jane M. Lucas, University of Idaho, Department of Soil and Water Systems, 875 Perimeter Drive MS 2340, Moscow, ID 83844-2340, Phone: 612-718-0699, Email: janelucas@uidaho.edu

Abstract

Background/Question/Methods

Soils contain immense diversity and support terrestrial ecosystem functions, but they face numerous anthropogenic pressures. Understanding how soils will respond to multiple stressors is critical for maintaining biodiversity and function. Here, we examined how introductions of low and high doses of the livestock antibiotic Monensin shape soil communities, and how these effects are exacerbated by shifts in soil temperature. Soils were collected from native uncultivated prairie, and maintained in microcosms that were incubated at 15, 20 or 30oC. Soil respiration was measured bi-weekly for 3 weeks. After our 21-day incubation, soil microbial communities were monitored with amplicon sequencing and qPCR, and soil nutrient characteristics were examined.

Results/Conclusions

We found that antibiotics and rising soil temperatures interacted to disrupt bacterial communities and connectivity. This allowed for a rise in fungal dominance and a change in soil nutrient stoichiometry. Independent of temperature, antibiotics decreased microbial efficiency and increased bioavailable C. Warming temperatures alone homogenized soil fungal communities and increased soil respiration and microbial biomass C. These results emphasize that as soils encounter multiple stressors, ecosystem efficiency, stability and resilience may be diminished.

Exploring the Novel Use of LiDAR-derived Terrain Information in Soil Mapping to Support Forest Management

Babak Kasraei, Brandon Heung*, Margaret G. Schmidt, Chuck E. Bulmer, Jin Zhang, William Bethel
Affiliations
Babak Kasraei, Soil Science Lab, Department of Geography, Simon Fraser University, 8888 University Drive, Burnaby, BC, V5A 1S6, Canada, Babak_Kasraei@sfu;
Brandon Heung*, Department of Plant, Food, and Environmental Sciences, Faculty of Agriculture Dalhousie University, PO Box 550, 21 Cox Rd., Truro, NS, B2N 5E3, Canada, Brandon.Heung@dal.ca;
Margaret G. Schmidt, Soil Science Lab, Department of Geography, Simon Fraser University, 8888 University Drive, Burnaby, BC, V5A 1S6, Canada, Margaret_Schmidt@sfu.ca;
Chuck E. Bulmer, British Columbia Ministry of Forests, Lands, Natural Resource Operations & Rural Development Vernon, BC, V1B 2C7, Canada, Chuck.Bulmer@gov.bc.ca;
Jin Zhang, Soil Science Lab, Department of Geography, Simon Fraser University, 8888 University Drive, Burnaby, BC, V5A 1S6, Canada, jza18@sfu.ca;
William Bethel, Soil Science Lab, Department of Geography, Simon Fraser University, 8888 University Drive, Burnaby, BC, V5A 1S6, Canada, William_Bethel@sfu.ca
*Corresponding author

Abstract:

The goal of sustainable forest management is to conserve biological diversity and maintain forest ecosystem productivity. LiDAR can be used to collect information for forest inventories, biomass monitoring and ecosystem modelling. Development of new digital mapping technologies has increased our ability to monitor soil properties and changes within them. To generate digital soil maps, a numerical model is used to relate field soil observations and environmental variables to make new predictions for all areas to be mapped. High-resolution topographic data derived from LiDAR have been used for mapping non-forested regions. However, there are only a few instances in which LiDAR derived DEMs have been used for mapping forest soils over large areas. The objectives of this study were 1) to produce digital soil maps for five soil properties: soil thickness, depth to carbonates, soil pH, coarse fragment content and soil clay content; 2) to validate model predictions using the k-fold cross validation method; and 3) to discuss and illustrate how these maps can be useful for forest management and soil degradation prevention. The study area was the Eagle Hill Forest, located west of Kamloops, British Columbia (BC), Canada (95 km^2). Covariates were derived from 1 m spatial resolution LiDAR data. A Random Forest model was used to predict five soil property and maps were produced. A nested 10-fold cross validation with 20 repeats was conducted to estimate the accuracy of maps. The best validation results were obtained for modelling soil thickness with R^2 of 0.35 and concordance of 0.47. The soil maps for individual properties can be used directly in forest management or can be used to prepare interpretive maps such as maps of compaction and puddling hazards.

Building an enhanced provincial database of soil information and analytical data in BC: a call for collaboration and contribution

J. Zhang[1,4], C. Bulmer[2], D. Filatow[3], M. Schmidt[4], B. Heung[1], A. Arbor[4], B. Kasraei[4], F. Chen[1]

Affiliations:

[1.] Department of Plant, Food, and Environmental Sciences, Dalhousie University. Truro, NS, B2N 5E3

[2.] British Columbia Ministry of Forests, Lands, Natural Resource Operations, and Rural Development

[3.] British Columbia Ministry of Environment & Climate Change Solutions

[4.] Department of Geography, Simon Fraser University. Burnaby, BC, V5A 1S6

Often, soil scientists find it challenging to access available datasets and soil information to facilitate their research projects, especially as soil research has been adapted to use machine-learning and Big Data techniques. The existing datasets are hosted by provincial, federal, academic, and industry resources. At the federal level, there are the National Soil Database (NSDB), detailed soil surveys, the Canada Land Inventory (CLI), and the Soil Landscapes of Canada (SLC)—all nested within the Canadian Soil Information Service (CanSIS). At the provincial level, the British Columbia Soil Information in BC (BCSIS) is the leading initiative, designed to preserve historically collected soil survey reports, soil information, and analytical data from past survey projects. Additionally, there are data collected for various soil research projects hosted at different institutes. Each system has its own data structure and is stored in different formats. Although there is an abundance of data available, these systems are not integrated or linked. As soil scientists, we are constantly searching and trying to extract information that we can use and integrate with our research to enhance our understanding of soil and sustainable resource management. The mechanisms to connect data with soil researchers are not very clear. In the process of building the BC SOIL 2020 repository, we aim to achieve two goals. First, to develop a system and a workflow to build a common data structure to host available datasets and with automated processes to integrate with other soil information systems. The second is to solicit additional data contributions to enhance the information richness and support other soil research projects.

Corresponding author: Jin Zhang (jza18@sfu.ca)

Useful terrain attributes for predictive soil mapping in the prairie landscapes of Saskatchewan

Jeremy Kiss[1], Preston Sorenson[1], and Angela Bedard-Haughn[1]
[1]Department of Soil Science, University of Saskatchewan

The unique morphology of prairie landscapes requires special consideration when selecting terrain attributes to use as predictor variables in predictive soil mapping (PSM) models. Terrain attributes developed to quantify higher relief landscapes in other parts of the world are not always well suited for prairie landscapes. As the prairie landscapes of Saskatchewan are relatively young in glacial terms and have relatively low relief, the time and forces necessary to develop traditional drainage networks (like rivers and streams) are often lacking. Terrain attributes that account for more complex interactions between topography and water movement are better suited for use in these types of landscapes. We summarize approaches that have worked well in PSM studies in the Saskatchewan prairies, including commonly cited methods like SAGA's *Relative Heights and Slope Positions* and *SAGA Wetness Index* modules (Conrad et al., 2015, Geosci. Model Dev. 8:1991-2007) and *LandMapR* (MacMillan et al. 2003, Fuzzy Sets and Sys. 13(2000):81-109). We also discuss attributes specifically developed in our work to characterize prairie pothole wetlands common in prairies landscapes. By understanding our landscapes and how best to quantify them, we can generate PSM models that are built on foundations of pedological principals and are better able to generalize to a variety of prairie landscapes and conditions.

Predictive Soil Mapping Using Historic Bare Soil Composite Imagery and Legacy Soil Survey Data

P.T. Sorenson[1,3], S.J Shirtliffe[2], A.K. Bedard-Haughn[1]

[1] Department of Soil Science, 51 Campus Drive, University of Saskatchewan, Saskatoon, Saskatchewan S7N 5A8

[2] Department of Plant Sciences, 51 Campus Drive, University of Saskatchewan, Saskatoon, Saskatchewan S7N 5A8

[3] Corresponding author: Preston Sorenson (preston.sorenson@usask.ca)

There is an increasing need for detailed soil property maps to support land use planning, soil carbon accounting and precision agriculture. While soil maps exist in Saskatchewan, they are at coarser scales (1:100,000), which are not always suitable for detailed soil management. One emerging technique for predictive soil mapping is the use of bare soil composite imagery derived from multi-temporal satellite imagery. This study focused on using bare soil composite imagery along with legacy soil data (1958-1998) with high location uncertainty to predict soil organic carbon, clay, and cation exchange capacity. The bare soil composite images were created from Landsat 5 imagery (1985 to 1995) using Google Earth Engine. Predictive models were then built using a Random Forest model for each parameter and evaluated using a 75-25 train test split. The soil organic carbon model had an R^2 value of 0.55 with a root mean square error (RMSE) of 0.67 percent, with the near infrared and visible light bands being the most important features in the model. The clay predictive model has an R^2 of 0.50 and a RMSE of 4.8 percent, with the shortwave infrared and thermal infrared bands being most important. The cation exchange capacity model had an R^2 of 0.51 with a RMSE of 5.6 meq 100 g^{-1}, with the shortwave and near infrared bands as the most important predictors. Based on these results, bare soil composite imagery represents a valuable covariate for predictive soil mapping in the Canadian Prairies.

cLHS-size: a technique to quickly determine minimum sample size for the cLHS algorithm

Daniel D. Saurette[1,2], Asim Biswas[1]*, Richard Heck[1], Adam Gillespie[1], and Aaron Berg[3]

[1] School of Environmental Sciences, University of Guelph, Ontario, Canada

[2] Ontario Ministry of Agriculture, Food and Rural Affairs, Guelph, Ontario, Canada

[3] Geography, Environment & Geomatics, University of Guelph, Ontario, Canada

*Corresponding author:

Address: School of Environmental Sciences, University of Guelph, Canada

Email: biswas@uoguelph.ca

Tel: +1 519 824 4120 Extn. 54249; Fax: +1 519 837 0756

Abstract: In digital soil mapping (DSM), a fundamental assumption is that the spatial variability of the target variable can be explained by the predictors or environmental covariates. Strategies to adequately sample the predictors have been well documented, with the conditioned Latin Hypercube Sampling (cHLS) receiving the most attention in the DSM community. Despite advances in sampling design, a critical gap remains in determining the number of samples required for a DSM project. We propose a simple workflow, and function coded in R language, to determine the minimum sample size for the cLHS algorithm based on histograms of the predictor variables using the Freedman-Diaconis rule for determining optimal bin width. Data pre-processing was included to correct for multimodal distributions and data not normally distributed, since these can affect sample size determination from the histogram data. Based on a user-selected confidence interval (CI) for the sample plan, the density of the histogram bins at the upper and lower bounds of the CI are used to determine minimum sample size. The technique is applied to a field-scale set of environmental covariates for the Smeltzer study site and tested across a range of CIs. The results show increasing minimum sample size with an increase in the CI selected. Minimum sample size increases from 44 to 83 samples from the 50% CI to the 95% CI, then increases exponentially to 194 samples for the 99% CI. The technique provides an estimate of minimum sample size that can then be used as an input to the cLHS algorithm.

Developing Soil Property (Soil Organic Carbon) Map from the Disaggregated Map of the Legacy Soil Maps of Middlesex County, ON

Authors: Tahmid Huq Easher[1], Emma Chappell[1], Daniel Saurette[1], Asim Biswas[1]

1. School of Environmental Sciences, University of Guelph

Abstract

Soil Property Maps, especially Soil Organic Carbon (SOC) data, play an integral role in forming and implementing policies at the regional and national level, and for making the appropriate and reliable decision at the farm-level to mitigate greenhouse gases from agricultural activities. In Ontario, soil survey and county reports (also known as legacy soil maps) dated back in the 1980s and 90s are the main source of this soil data which need to be sample, tested, and updated to know the current state of the soil. In response to that OMAFRA took the initiative “New Horizon” in “Sustaining Ontario Agricultural Soils” and one of the goals is to generate reliable soil data and tools to allow for informed decision-making and analysis. It is a time-demanding and resource-intensive activity to generate updated data, which is still under process. In the meantime, the authority requires an alternative way to gather soil information to take actions not only to mitigate climate change but also to manage agricultural land uses to meet the rapidly growing food demand. In these regards, this study is focused on developing a soil property map (in this case only soil organic carbon) using the legacy maps and data of Middlesex County, ON. The soil survey data and county maps of Middlesex are polygon-based and each polygon contains one or multiple soil type units. They contain the proportions, environmental conditions, and soil characteristics (soil type, texture, properties like pH, SOC, etc.) in a detailed database, but don’t contain any graphical representation of the distribution of the soil type units. In this study, Digital Soil Mapping (DSM) techniques are used to disaggregate these compound polygon-based maps into point-based raster digital soil maps to predict the soil classes of each geographical point. Then based on soil survey data and county reports, the average and range of values of SOC for each soil class are assigned into the disaggregated soil class maps to develop a predictive SOC map. Then the maps are validated using existing data points extracted from the county reports and will be compared using statistical methods, to explore the acceptance of this method. Thus this presentation will focus on showcasing the result of this method in predicting SOC from disaggregated soil maps, the benefits, and drawbacks of this approach, and the potential of this method to be used in predicting other soil properties.

Combining EMI Measurements of Electrical Conductivity and Magnetic Susceptibility to better Characterize Soil Drainage

Farzad Shirzaditabar[1*], Richard J. Heck[1] and Mike Catalano[2]

[1]School of Environmental Sciences, University of Guelph, Guelph, Ontario, Canada

[2]Geonics Ltd., Mississauga, Ontario, Canada

[*]fshirzad@uoguelph.ca

The characterization of soil drainage class or moisture regime may done by direct monitoring of local groundwater table, moisture fluctuations in the vadose zone, or interpretation of natural vegetation, but these require considerable installations or specialized understanding of regional ecology. For most practice applications, including mapping, hydromorphic features such as gleying and mottling, reflecting the distribution of Fe oxides in the profile (in pits or auger holes), are often used as indicators of long-term soil conditions, but this is labor, intensive and tedious. The use of in-field measurements of soil electrical conductivity (EC) by electromagnetic induction -EMI (such as the Geonics EM38), to better delineate soil according moisture dynamics or salinity (where present), has been demonstrated and is used widely. In contrast, the ability of EMI instruments to measure magnetic susceptibility (MS), reflecting soil hydromorphism has attracted less attention. The main purpose of this work is interpreting the apparent EC and MS data, measured by an EMI instrument in order to delineate soil drainage conditions. To do this, soil EC and MS in six selected points, with different drainage conditions, were measured five times during July 2020 using EM38-MK2, in both vertical and horizontal modes. Comparing the findings clarifies that higher MS values mostly belong to well-drained soils whereas poorly drained soils show lower MS values. This is because anaerobic and intensely reducing conditions, found in hydric soils, enhance the dissolution of highly magnetic minerals, like magnetite and maghemite. Thus, the MS values are naturally very low in poorly drained soils around the world. Besides, poorly drained soils generally show higher EC values, whereas well-drained soils have lower ones, which somehow reflect higher and lower soil water contents, respectively. So, EMI instruments can be utilized to more easily delineate soil drainage conditions in the field. Moreover, since EMI measurements are done without any contact between the instrument and soil surface, it would be easier to obtain information about the seasonal dynamics, rather than single observations in open pits or auger holes.

Modeling total and active organic carbon dynamics using digital soil mapping

Siddhartho S Paul[1,2]*, Brandon Heung[1], Derek Lynch[1]

[1]Department of Plant, Food, and Environmental Sciences, Dalhousie University, Canada. [2]Department of Forest Ecology and Management, Swedish University of Agricultural Sciences, Sweden. *Email: siddhartho.paul@gmail.com

Soil organic carbon (SOC) dynamics are key to understanding soil health and agricultural productivity. Time-series remote sensing data and digital soil mapping (DSM) tools are becoming increasingly powerful for producing continuous soil maps and can effectively monitor SOC dynamics. It is also critical to monitor the dynamics of active organic carbon pool (e.g. permanganate oxidizable carbon), as this is the most sensitive fraction of total organic carbon (TOC) against land use changes and a key soil health parameter. Across a 37 km^2 study area in Truro, Nova Scotia, we applied DSM techniques to (1) assess changes in TOC (2015-2019); (2) assess changes in potassium permanganate oxidizable carbon (POXc); and (3) evaluate different land use practices that contributed to TOC and POXc dynamics. We developed a suite of soil and vegetation indices from Landsat satellite images; topographic variables from light detection and ranging (LiDAR) data; and incorporated crop inventory data over a period from 2012 to 2019. Random Forest (RF) and Stochastic Gradient Boosting Model (GBM) were used to predict TOC and POXc and the model performance was evaluated using 10-fold cross-validation. Both models performed equally well for TOC and POXc predictions; however, RF was marginally better for some accuracy measures. TOC prediction was more accurate compared to POXc prediction, with a concordance of 0.70 for TOC and 0.54 for POXc. In 2019, TOC ranged from 11.75 to 42.47 g/kg while POXc varied from 310.44 to 891.71 mg/kg, with the highest values for both obtained under continuous pasture, grassland, and forage production. In contrast, fields rotated between forage and other annual crops had the lowest TOC and POXc. 72% of the study area observed no-change in TOC during the study period whereas TOC losses occurred in 27% of the area and was gained in 1%. In contrast, POXc was more dynamic with losses and gains of 65% and 33%, respectively. Annual crop fields exhibited the most losses in TOC and POXc. These findings highlight that POXc is more sensitive to changes in land use and agricultural management even during a short period; and the application of DSM to monitor both TOC and POXc for effective soil organic matter and soil health management.

Ivermectin in cow dung affects soil microarthropods, microbial biomass and enzyme activity in grasslands

Newton Lupwayi[1]*, Derrick Kanashiro[1], Andrea Eastman[2], Kevin Floate[1] and Xiying Hao[1]
Agriculture & Agri-Food Canada, [1]Lethbridge Research & Development Centre, Lethbridge, Alberta; [2]Beaverlodge Research Farm, Beaverlodge, Alberta
*Presenter: newton.lupwayi@canada.ca

Ivermectin is a widely used veterinary drug to control internal and external cattle pests through its anthelmintic and insecticidal properties. Cattle administered with ivermectin excrete >80% of it in the dung, where they can be toxic to dung-breeding insects and slow down dung decomposition and nutrient return to the underlying soil. On a native grassland in southern Alberta in 2016-17 and 2017-18, we investigated the effect of ivermectin on the abundance of underlying soil microarthropods, which are primary decomposers, microbial biomass C (MBC) and activities of enzymes that mediate C, N, P and S cycling. There were three treatments: dung pats treated with ivermectin ($Dung^{Iv}$), dung pats without ivermectin (Dung), and bare soil (Control). Soil cores (100 cm^3) were collected periodically over 52-wk periods starting one week after pat placement in May of each year, and the soil was analysed for microarthropod abundances, MBC and enzyme activities. Averaged over all treatments, the abundances of soil microarthropods were in the order (counts/100 cm^3): Prostigmata (211 for Tydeidae and 100 for others) > Acaridae (45) > Mesostigmata (16) > Oribatida (4) = Nematodes (4) = Collembola (1). Ivermectin reduced the abundances of nematodes (Dung > Control = $Dung^{Iv}$), Mesostigmata (Dung > $Dung^{Iv}$ > Control) and Collembola (Dung > $Dung^{Iv}$ = Control). However, Prostigmata, Oribadida and Acaridae were not affected by Ivermectin even though the dung itself increased their abundances relative to the Control (all $Dung^{Iv}$ = Dung > Control). Ivermectin reduced MBC (Dung > $Dung^{Iv}$ = Control), but increased the activity of the C- and N-cycling enzyme N-acetyl-β-glucosaminidase (NAG) ($Dung^{Iv}$ > Dung = Control). A common NAG substrate is chitin, found in arthropod exoskeletons and fungal cell walls. Therefore, ivermectin in cattle dung probably affected nutrient cycling in the underlying soil by reducing MBC and the abundances of nematodes, Mesostigmata and Collembola, and by increasing the activity of a C- and N-cycling enzyme that presumably recycled N from the arthropods killed by ivermectin.

Can the Denitrification-Decomposition model help with determination of optimal duration of grassland set-asides in Delta, BC?

Patricia Hanuszak1, Maja Krzic1, Lewis Fausak 1, Steven Siciliano2, Sean Smukler1
1Soil Science, Faculty of Land and Food Systems, University of British Columbia, Vancouver, BC, V6T 1Z4, Canada, Unceded xʷməθkʷəy̓əm Musqueam Territory; 2Soil Science, College of Agriculture and Bioresources, University of Saskatchewan, Saskatoon, SK, S7N 5A8, Canada, Treaty 6 Territory

Short-term (1-4 years) grassland set-asides (GLSAs) are a conservation practice commonly used by farmers in Delta, BC to improve soil quality, as a part of crop rotation, or to transition to organic production systems. While there is increasing evidence that GLSAs are beneficial for subsequent crop production it is unclear what the optimal duration is to meet farmer's goals related to the practice and to preserve crop yields following GLSA implementation. The objective of this study is to determine the optimal GLSA duration based on soil nutrient dynamics and crop yields in the season following GLSA termination. Data on soil properties following 2, 3, and 4-year GLSAs were collected from 11 operational farms that had paired GLSA and adjacent annually cropped (ACR) fields of similar management history. In addition, data were also collected at two controlled field experiments. Between 2015 and 2019, a total of 25 fields were sampled for soil chemical and physical properties (at 0-15 and 15-30 cm depths) throughout the production season following GLSA termination and harvestable yields at the end of each season. Soil and crop yield data were used to calibrate and validate an agroecosystem model, Denitrification-Decomposition (DNDCv.CAN). The model results for post 2-year GLSA calibration fields overpredicted (125-175%) nitrate with moderate fit (r2 = 0.35-0.51) and underpredicted (30 – 60%) ammonium with poor fit (r2 = 0.01-0.15). Performance of GLSA was determined to be largely dependent on initial soil properties prior to planting rather than GLSA duration. The results of this study will help farmers to decide on the optimal GLSA duration based on the site history and soil baseline properties.

Soil health dynamics following restoration of pipeline corridors on agricultural land

Clemence Muitire[1*], Francis Zvomuya[1], and Inoka Amarakoon[1]
[1]Department of Soil Science, University of Manitoba, Winnipeg, Manitoba, Canada
[*]muitirec@myumanitoba.ca

Land disturbance due to pipeline construction can have adverse effects on vegetation and soil ecosystems. Many of the documented studies on the recovery of pipeline right-of-ways (ROWs) have focused on forested lands and grasslands, with little focus on agricultural land. Therefore, the objective of this study was to examine the effects of the length of time elapsed since reclamation of pipeline ROWs on soil health and crop productivity. We hypothesized that crop productivity and soil health are lowest along recently reclaimed ROWs and that these attributes gradually become similar to undisturbed benchmark sites with increasing time elapsed since reclamation was completed. To test this hypothesis, pipeline ROWs of varying ages (4, 8, and 10 yr since reclamation) were sampled for crop and soil variables across three sites and two seasons, focusing on three of the most widely grown crops in the Canadian Prairies: barley, canola, and field peas. In this presentation, the influence of pipeline corridor age on soil chemical, physical, and highly sensitive health attributes, will be presented.

Cultivation of Switchgrass and Reed Canarygrass on a Soil Contaminated with Trace Metal Elements.

LÉA FARRIER[1,2], ISABELLE ROYER[1], DENIS ANGERS[1], ANTOINE KARAM[2]
1 Quebec Research and Development Centre, Agriculture and Agri-Food Canada, 2560 Hochelaga Boulevard, Québec, QC.
2 Université Laval, Département des sols et de génie agroalimentaire, 2425 rue de l'Agriculture, Québec, QC.
Email: leafarrier@hotmail.com

Production of plant biomass for energy purpose is an expanding sector. In this context, its development on marginal lands should be considered to avoid competition for limited agricultural lands which are intended for the production of food for human and animal consumption. Trace metal elements (TME) represent 34% of contaminated sites in Canada and 46% in Quebec, respectively. The objective of this study was to determine the effect of soil contamination by Cu, Zn and Pb on switchgrass (SWG) and reed canarygrass (RCG) crops. The experimental design was a random complete blocks consisting of two treatments (two crops) with four replicates, and it was initiated in the summer of 2015. From 56 sampling points, contaminated (CZ, n = 21) and uncontaminated zones (UCZ, n = 35) were assigned. From 2016 to 2018, multiple sampling of above-ground biomass plant and soil properties was performed to assess the effect of the presence of TME on crops yield and to determine whether the uptake differs according to plant species. Yields varied between 3.2 and 6.8 T ha-1 for SWG and 1.9 and 2.7 T ha-1 for RCG. No significant differences in yield were observed between the two zones, except for SWG in 2016 where it was 1.5 T ha-1 higher in the CZ. For both crops, Cu concentrations were similar between the two zones. For Zn and Pb, they were higher in the CZ than in the UCZ. Total soil metal concentrations generally decreased from 2015 by 18% for Cu, 47% for Pb and 36% for Zn in contaminated plots under SWG. Total soil metal concentrations in the RCG plots also decreased by 32% and 30% for Cu and Pb, respectively and remained constant for Zn. The Mehlich-III-extractable metal concentrations decreased by 10% for Cu, 40% for Pb and 38% for Zn in the contaminated switchgrass plots whereas in reed canarygrass, they decreased by 5% and 17% for Cu and Zn, respectively and increased by 8% for Pb. We conclude that the cultivation of those two crops on metal-contaminated soils is possible without significant crop yield loss compared to uncontaminated soils. These results are promising for the use of marginal lands for the production of biomass for energy purposes.

Soil and vegetation properties following wellsite reclamation with suboptimal topsoil replacement depth and organic amendments

Takudzwa Nawu[1*], Francis Zvomuya[1], Inoka Amarakoon[1], Asfaw Bekele[2], and Michelle Young[2]

[1] Department of Soil Science, University of Manitoba, Winnipeg, Manitoba, Canada.

[2]Imperial Oil Resources Limited, 9223 23rd Street S.E., Calgary, Alberta, Canada.

*nawut@myumanitoba.ca**

Disturbances at wellsites and borrow sites are an unavoidable result of oil and natural gas extraction, which necessitate reclamation to restore and maintain the productivity to a level similar to that before the disturbance. The success of reclamation depends on the quality and quantity of topsoil replaced at these sites. However, most wellsites have insufficient salvaged topsoil to attain the regulated 80% topsoil replacement depth (TRD) for successful reclamation. The objective of this 5-yr study was to determine if topsoil depth, biochar and peat can augment reclamation success at sites where available topsoil is insufficient to attain the mandatory 80% TRD. Specifically, the study compared the effects of 50% TRD plus biochar, 50% TRD plus peat, non-amended 50% TRD, and unamended 80% TRD on soil and vegetation properties following reclamation at a site near Cold Lake, Alberta. Amendments were applied at the start of the experiment at organic carbon rates equivalent to those in the non-amended 80% TRD treatment. Tree and shrub seedling mixes were transplanted in all plots. Soil properties and vegetation attributes were measured annually for 5 yr. Compared to 50% TRD and 80% TRD, peat significantly increased total Kjeldahl nitrogen concentration by 58%, while biochar produced significantly greater potassium concentrations in plots reclaimed with 50% TRD. Peat and biochar significantly increased TOC concentrations compared to the unamended plots. Graminoid and native canopy covers were significantly greater in peat-amended plots and 80% TRD plots than in biochar-amended plots. Similarly, the peat-amended 50% TRD and the 80% TRD treatment significantly increased native species richness by 12% relative to the biochar-amended 50% TRD treatment. Our findings show that peat and biochar organic amendments can improve reclamation success at disturbed boreal sites when salvaged soil is insufficient to achieve the optimal 80% TRD.

Cleaning Up Heavy Metals Using Carbon Based Materials

Yihan Zhao[1] and M Anne Naeth[1]

Department of Renewable Resources, University of Alberta, Edmonton, Alberta

Abstract:

Excessive release of heavy metals may pose a significant risk to the environment and public health. Soil and water can be contaminated with heavy metals from many industrial activities, such as coal mining. Conventional methods of treating heavy metals are usually high energy requirements, low efficiency, and expensive. Therefore, developing an efficient, rapid, and cost-effectively method for heavy metal remediation is critical. Nano Humus is a coal-derived humic substances product. The main component of nano humus, humic substances, are natural organic compounds and considered the most reactive organic carbon fraction. Nano humus features a large pore volume which provides a relatively higher surface area and unique electrical properties. It has chemically reactive functional groups which could enhance the metal adsorption. It is cost effective as the raw materials (coal) can be achieved on coal mine sites at low costs. Owing to these characteristics, nano humus has a high potential in removing heavy metal contaminants. The primary objective of this study was to investigate the use of nano humus in the removal of Cd(II), Zn(II) from artificial metal contaminated water. The effects of initial metal concentration and contact time were also studied. A batch sorption experiment was conducted at room temperature to evaluate the sorption properties of the studied material nano humus. Heavy metal solutions were prepared from cadmium and zinc salts at 5 different concentrations, from 25 to 125 mg/L (pH at 7). A volume of 20 ml single elemental solutions was added to 0.02g of nano humus. Then, place the mixtures on a shaker for 24 hours to reach equilibrium. Isotherm data of Cd(II) and Zn(II) fitted well for the Freundlich model, indicating multilayer adsorption dominated for nano humus. Adsorption of metal ions is dependent on their initial concentrations and contact time at neutral pH. After treatment, the levels of metal ions were observed to decrease by 83.1 - 99.6% for Cd(II) and 57.6 - 98.3% for Zn(II). The percentage removal decreased with the increase in the initial concentration. The order of affinity which represents the adsorption capacity decreased in the order of Cd(II) > Zn(II). The effect of contact time on the Cd(II) adsorption at different time intervals of 15 mins, 30 mins, 1 hr, 3hrs, 6 hrs, 9hrs, 24 hrs showed that 89.1% of Cd(II) in the solution was adsorbed in 15 minutes and the removal gradually reached at 92.8% with the increase of contact time. Nano humus appears to be a promising adsorbent for the removal of Cd(II) and Zn(II) ions from water. The use of nano humus may reduce remediation costs resulting from the utilization of low cost humic products derived from coal in treating contaminated soil or water.

Post-disturbance conifer tree-ring $\delta^{15}N$ reflects openness of the nitrogen cycle across temperate coastal rainforests

JM Kranabetter, British Columbia Ministry of Forests, Lands, Natural Resources Operations and Rural Development (marty.kranabetter@gov.bc.ca)
BJ Hawkins and K McKeown, University of Victoria

Post-disturbance losses in nitrogen (N) may diminish forest productivity, and soils with inherently 'open' N cycles are considered the most vulnerable to leaching losses of NO_3^-. Monitoring ongoing N depletion from soil profiles is challenging, but tree-ring $\delta^{15}N$ of regenerating stands may offer an effective method for assessing site-specific, long-term soil N dynamics. Evidence to date is mixed, however, and includes increasing, unchanging, or decreasing tree-ring $\delta^{15}N$ in young stands following stand-level disturbances, possibly because of contrasting soil N availability among study sites. We compared tree-ring $\delta^{15}N$ of two conifer species (*Picea sitchensis* with ectomycorrhizal fungi and *Thuja plicata* with arbuscular mycorrhiza) from a replicated silviculture trial across temperate rainforests of Vancouver Island (Canada). A natural gradient in soil N status across the six sites, driven largely by topography and parent materials, was demonstrated by *in situ* increases in N mineralization and nitrification rates with declining C:N ratios for both organic horizons and mineral soils. Five decades after timber harvest, the overall trend in tree-ring $\delta^{15}N$ was positive, indicating a loss of nitrate from the system, but among individual plots the slope of $\delta^{15}N$ ranged from nearly 0 to 0.13. We found the gains in tree-ring $\delta^{15}N$ with time were consistent between mycorrhizal types and escalated (up to 6‰) with increasing N mineralization, although less so on flat terrain with seasonal water tables. The most recent sapwood was also enriched in ^{15}N on soils with higher N mineralization rates, perhaps slightly more so for *T. plicata* than *P. sitchensis*. The alignment of tree-ring $\delta^{15}N$ with soil N cycles may be especially strong in regenerating forests because of ontogeny effects, including the expansion of rooting depth and increases in N resorption efficiency with stand age. Sharp increases in tree-ring $\delta^{15}N$ underscore the vulnerability of low C:N soils with open N cycles to post-disturbance N losses, and highlight how multiple, frequent harvesting cycles may risk substantial N depletion from these productive rainforest ecosystems.

The Effects of Decadal Climate Change on Recharge Rates in Semi-arid Environments

Authors: Anne Paquette*, Bing Cheng Si.
Department of Soil Science, University of Saskatchewan, SK, Canada.
*Corresponding author: anp807@usask.ca

The effects of climate change on recharge rates is an important consideration when attempting to manage water resources in semi-arid environments. It is essential to get accurate representation of the recharge rates so that appropriate precautions and mitigation practices can be put in place to protect the freshwater resources. Previous research has demonstrated that climatic variability can alter the soil water dynamics and groundwater recharge of water-limited environments. We hypothesized that recharge rates are not uniform and will vary relative to consecutive wet and dry years. The objective of this study is to determine if there have been significant changes in recharge rates from 1994 to 2019 and if these changes coincide with wet and dry periods seen in the past decade. The current study builds on pre-existing long term (decadal) tracer data from a water-limited cropland in Laura Lake, Saskatchewan. The recharge rates monitored for this site have been observed from 1923 to present day, giving a long-term data set that can indicate changes in recharge rates relative to wet and dry periods. The root density and volumetric water contents were measured at 15 cm intervals to determine the crop root distribution. The depth-to-peak concentration method was used to estimate the groundwater recharge rates from two applied tracers, chloride and nitrate. The results of this study demonstrated that recharge rates coincide with long term dry and wet periods. The mean recharge rate for long term dry conditions from 1994 to 2003 was 0 cm yr^{-1}, and for long term wet conditions from 2003 to 2017 was measured at 3.75 cm yr^{-1}. The mean recharge rate of the wet period was 1% of the average annual precipitation, which is higher compared to the 0% of the dry years. The results of our findings suggest that during drought conditions in semi-arid environments there is no water movement halting the movement of the applied tracer. These results can have further implications on how accurate applied tracers can be when determining future paleoclimates in water-limiting environments.

Prairie Problems: When diagnostic features don't tell the whole story

Angela Bedard-Haughn, PhD, PAg
Department of Soil Science, University of Saskatchewan, Saskatoon, SK
angela.bedard-haughn@usask.ca

I am fond of saying that soils tell stories, and that soil classification provides a convenient shorthand for sharing those stories with fellow soils enthusiasts. Unfortunately, soil classification does not always capture important subplots – or even worse, carefully following the soil classification keys like a "choose-your-own-adventure" novel can sometimes lead you into an entirely confusing plot line and leave you wondering where you flipped to the wrong page! Seasoned surveyors can readily apply their wealth of tacit knowledge to ensure that the ultimate classification reflects the soil-forming environment and dominant soil-forming processes. However, plot quirks can become quandaries when teaching students in the field   This presentation will cover a few of the fun discussions I've had, such as: This must be a Brunisol, the A horizon isn't thick enough to be a Chernozem! Carbonated Gleysol – is that an energy drink? And a frequent discussion on pasture hillslopes: Is this a Cumulic Regosol or an Orthic Brown Chernozem – and why should I care?

At its core, soil classification is a Soil Scientists use to understand the world. Like all models, soil classification is an abstraction and simplification of reality. The narrative students create in their soil stories needs to fit not just a model meant to ease understanding and communication, but also the overall plot created by the landscape.

RE-EXAMINATION OF DRAINAGE CLASSES IN COARSE-TEXTURED NON-HYDROMORPHIC SOILS

Authors: C. James (Jim) Warren[1,2], Daniel D. Saurette[1,2], Richard. J. Heck[2]

[1]Ontario Ministry of Agriculture Food and Rural Affairs, 1 Stone Road West, 3rd Floor SE Guelph, Ontario N1G 4Y2. [2]School of Environmental Sciences, University of Guelph, 50 Stone Road East, Guelph, Ontario N1G 2W1

ABSTRACT:

Drainage refers to the frequency and duration of wet periods, how quickly excess water is removed from the soil profile and is one of the central concepts used to differentiate soil series within the Canadian System of Soil Classification (CSSC). Currently seven drainage classes are recognized: very rapid, rapid, well, moderately well, imperfect, poor and very poor. In fine-textured hydromorphic soils, drainage class (moderately well, imperfect, poor and very poor) is typically differentiated based on morphological characteristics (i.e., gleying and mottles). For coarse-textured non-hydromorphic soils differentiation of drainage classes (very rapid, rapid, well) is based on available soil moisture which is inferred from soil texture and the abundance of coarse fragments; effectively particle size class. An additional consideration, which is not currently included in the definition of drainage class, is the presence of a lithic contact in proximity to the surface, which also limits plant available moisture. Available soil moisture values were calculated using a published pedotransfer function for combinations of sand, silt and clay-sized particles including very fine to very coarse sand sub-fractions as input. Increasing amounts of coarse fragment content and various values for depth to bedrock were also included in the calculations. Calculated values were compared with available moisture ranges currently assigned to drainage classes of non-hydromorphic textures and several inconsistencies were identified. Revisions are proposed to textural assessment of drainage in non-hydromorphic soils.

RATIONALIZING GLEYING AND MOTTLING OF CANADIAN SOILS

Authors: Richard J. Heck[1], Daniel Saurette[12], Jim Warren[2]

[1]School of Environmental Sciences University of Guelph, Guelph, Ontario, N1G 2W1. [2]Ontario Ministry of Agriculture Food and Rural Affairs, 1 Stone Road West, 3rd Floor SE Guelph, Ontario N1G 4Y2.

ABSTRACT:

The field description of gleying and mottling, in mineral soil profiles, is well-established in Canada, and is generally coherent with criteria used internationally. Ultimately, the presence of these features are reflective of spatial and temporal variations in redox conditions, resulting from prolonged saturation (of soil porosity by water), and subsequent development of anaerobic conditions by biological respiration. Within the Canadian System of Soil Classification, soils of the Gleysolic Order are distinguished principally by gleying in the top 50 cm, with variable requirements of mottling, depending on the hue of the soil. The application to other soil orders occurs at the subgroup level, to consider landscape continuums with Gleysols. The diagnostic thresholds for mottling in the non-gleyed minerals varies according to their order: for Solonetzes, Chernozems and Regosols, faint to distinct mottles are required within the top 50 cm; for Brunisols, faint to distinct within the top 50 cm, or distinct to prominent at 50 to 100 cm; for most Luvisols, distinct within the top 50 cm, or prominent at 50-100 cm; for Podzols, distinct to prominent with 100 cm of the surface; Gleyed Vertisols, with faint to distinct mottles within the top 50 cm, are distinguished from Gleysolic Vertisols, with prominent mottles within the top 50 cm. In contrast, the characterization of soil drainage class (e.g. Ontario) is independent of other pedofeatures: if the top 50 cm is gleyed with distinct or prominent mottles, it is poorly drained, without the mottles it is very poorly; if the top 50 cm is not gleyed, but has distinct or prominent mottles, or has prominent mottles at 50-100 cm the soil is imperfectly drained; other soils without gleying in the top 50, but with distinct mottles at 50-100 cm are considered moderately well drain. A similar approach is taken for the characterization of moisture regime, used in ecological land classification (e.g. Ontario). This presentation will focus on issues associated with inconsistencies in the application of gleying and mottling in soil classification in Canada.

ELEVATION OF SHALLOW SOILS WITHIN THE TAXA OF THE CANADIAN SYSTEM OF SOIL CLASSIFICATION

C. James (Jim) Warren[1,2], Daniel Saurette[1,2], Richard J. Heck[2], Louis-Pierre Comeau[3]

[1]Ontario Ministry of Agriculture Food and Rural Affairs, 1 Stone Road West, 3rd Floor SE Guelph, Ontario N1G 4Y2. [2]School of Environmental Sciences, University of Guelph, Guelph, Ontario, N1G 2W1 [3]Agriculture and Agri-food Canada, Fredericton Research and Development, 850 Lincoln Rd. Fredericton New Brunswick E3B 4Z7.

ABSTRACT:

Shallow soils occurring throughout the world, recognized as Leptosols in the World Reference Base (WRB), are characterized as having a lithic contact close to the soil surface. Within the Canadian System of Soil Classification (CSSC), shallow soils are currently classified at the family level according to the depth at which the lithic contact is encountered (<20, 20-50 and >50-100 cm); yet at the series level these soils are typically designated as a shallow phase of a non-shallow soil series. Shallow soils occur almost anywhere in Canada where glacial drift is thin, affecting all soil orders. The presence of shallow bedrock impacts drainage, as well as the amount of available moisture, and has a major influence on soil formation, management and production capability. Consequently, it is proposed that the importance of shallow soils be elevated within the CSSC to be consistent with the frequency of the occurrence of shallow soils in the landscape and to be consistent with other soil classification systems of the world. These changes will have a major impact on all orders of the CSSC and the current formal definition of soil. These proposed modifications include nullifying the 10 cm requirement as part of the current definition of soil in the CSSC for closer consistency with Ecological Land Classification. Possible options for modifications to the current key to the soil orders, great groups and subgroups will be presented and discussed.

Surface Organic Horizons for Chernozemic Soils Don't Get No Respect (Rodney Dangerfield)!

J.J. Miller[1]*, D.S. Chanasyk[2], and R.L. McNeil[3]

[1]Agriculture and Agri-Food Canada (retired), Lethbridge, Alberta; [2]Professor Emeritus, University of Alberta, Edmonton, Alberta; [3]Contract Pedology Services Ltd., Lethbridge, Alberta

In the Canadian system of soil classification (CSSC), organic soil horizons can be designated as LFH horizons for forest soils, or as O horizons for peatland soils. For Chernozemic soils, organic surface horizons can only be applied to two grassland-forest transition subgroups as LFH horizons. Currently no organic soil horizon designation exists for surface, organic layers of Chernozemic soils under native grassland, long-term forages, no-till fields, or other cases where organic material in various stages of decomposition can build up at the soil surface. Despite this, some pedologists apply the LFH designation to organic layers for Chernozemic soils because the CSSC does not explicitly state that it cannot be applied to these soils. Possible options to expand the use of organic soil horizons for Chernozemic soils include: (1) to broaden the definition of LFH horizons to include Chernozemic soils; (2) to use the O horizon designation; or (3) to create a new master organic horizon for Chernozemic soils. Many studies report the thickness and properties of LFH horizons for forest soils and O horizons for peatland soils. In contrast, studies on Chernozemic soils rarely report the thickness and properties of litter, thatch, or crop residue layers; and the organic horizon is generally ignored. This occurs despite research that clearly shows that crop residues constitute a fully-fledged microbial ecosystem with high numbers and diversity of bacteria and fungi; and that these mulch layers significantly influence soil properties. We propose allowing organic surface layers in all Chernozemic soils to be classified as organic horizons (where applicable). In addition, soil scientists should report the depth, sample these horizons, and report the properties of these important organic horizons where they exist. Although soil taxonomic systems are designed to be resilient and unaffected by short-term soil change, agriculture and other human activities (e.g., Anthroposols) can change soil classification over relatively short pedological time scales. As Rodney Dangerfield might say if he was a pedologist, "surface organic horizons for Chernozemic soils deserve more respect!"

Better recognition of limnic materials and proposed modifications to the Organic Soil Order of the Canadian System of Soil Classification

Authors: Daniel Saurette[1,2], and Raphaël Deragon[3]

[1]Ontario Ministry of Agriculture Food and Rural Affairs, 1 Stone Road West, 3rd Floor SE Guelph, Ontario N1G 4Y2. [2]School of Environmental Sciences, University of Guelph, Guelph, Ontario, N1G 2W1. [3] Département des sols et de génie agroalimentaire, Université Laval, Québec, QC, G1V 0A6

Organic soils make up approximately 10% of the Canadian land mass and support important agricultural regions in Canada. The Saint-Lawrence plain south of Montreal has 145,000 hectares of deep organic soils and 24,000 hectares of shallow organic soils. Specialty crop production in organic soils, focused on root and leafy vegetables, is critically important to the agricultural sector in this region, with high-value crops destined for markets in Montreal and New York State, generating 50% of agricultural revenues on only 3-4% of the agricultural land base. A significant portion of the organic deposits in the region are underlain by coprogenous earth, a type of limnic deposit typically found between the organic horizons (Of, Om or Oh) and the mineral contact, and is deposited in deep standing water as a mixture of plankton, fecal pellets, plant and animal residues, and mineral particles. These materials can have many negative physical and chemical properties that render them not suitable for sustaining crop production, and they are at increased risk of being exposed at the surface with subsidence of the peat due to drainage, and continued losses of surface organic materials from microbial decomposition (1.25 cm yr^{-1}) and wind and water erosion (1.25 cm yr^{-1}). Within the Canadian System of Soil Classification, limnic materials are recognized at the Subgroup level, and can be further differentiated at the Family level (coprogenous, diatomaceous, marl) to describe the type of limnic material present in the control section. Currently, the recognition of limnic materials is not possible when a soil profile meets the requirements for the *Terric* subgroup. We propose modifications to the Organic Soil Order, within the Fibrisol, Mesisol and Humisol Great Groups, at the Subgroup level to allow recognition of both *Terric* and *Limnic* soil profile features (e.g., Terric Limnic Fibrisol, Terric Limnic Mesisol, Terric Limnic Humisol). We support these proposed modifications by establishing an estimated extent of these soils in Quebec and Ontario, and by providing soil profile morphological descriptions from field soil survey activities.

PROPOSED CHANGES TO THE SOIL FAMILY TAXA WITHIN THE CANADIAN SYSTEM OF SOIL CLASSIFICATION

Authors: C. James (Jim) Warren[12], Daniel Saurette[12]

[1]Ontario Ministry of Agriculture Food and Rural Affairs, 1 Stone Road West, 3rd Floor SE Guelph, Ontario N1G 4Y2. [2]School of Environmental Sciences, University of Guelph, Guelph, Ontario N1G 2W1

ABSTRACT:

The soil family was developed in the 1960s as the fourth level of taxa within the hierarchical structure of the Canadian System of Soil Classification. The aim of the soil family category is to provide a framework for checking and establishing limits for Soil Series while providing a link between the series and the subgroup levels. Its intended use was to define and group numerous soil series for the purposes of management. Classification of mineral soils at the family level is based on properties of the parent materials including particle size which includes texture; soil mineralogy; reaction and calcareousness; depth to bedrock and/or permafrost; soil temperature and soil moisture regimes. The soil family particle size classes were originally intended as a compromise between agronomic and engineering influences; however, the resulting particle size classes have limited functionality as they frequently subdivide soil textural classes. Consequently, classification at the family level has largely been ignored. Some adjustments to the family taxa for mineral soils are proposed including realignment of classes in the current family particle size triangle to follow class divisions of the soil textural triangle along with minor adjustments to mineralogy classes and depth to bedrock.

Southwest of Montreal Organic soils: Pedology and characterization of physicochemical and hydrodynamical properties

Raphaël Deragon, Michaël Leblanc, Jean Caron
Université Laval, Québec, Qc, Canada (email : raphael.deragon.1@ulaval.ca)

Reclaimed Organic soils cover thousands of hectares in Canada and are mainly used for horticulture. Agricultural exploitation of Organic soils leads to the evolution of peat properties by decomposition, settlement, and erosion. In the Southwest region of Quebec, annual soil loss reaches up to 1 to 4 cm and shortens the life expectancy of these productive peatlands, estimated at 30 to 50 years. The aim of this study is to evaluate the soil quality of 14 farms to guide the application of conservation methods. The principal hypothesis is that physico-chemical and hydrodynamic properties of Organic soils are correlated with pedological characteristics. Specific objectives of this study are 1) to characterise soil properties to monitor soil health evolution, 2) to define soil management groups based on discriminant soil properties, 3) to map these groups to target fields for a prioritized intervention.

In 2019, 120 soil profiles were studied in both problematic fields and fields that offer good yields for a comparative analysis. Characterisation of physical and hydraulic properties (retention curve, saturated hydraulic conductivity, bulk density, soil layers thickness, soil penetration resistance) and chemical properties (total nitrogen, total carbon, loss on ignition, electrical conductivity, and pH) was done. The degree of decomposition was evaluated with the rubbed fibers field method and with the sodium pyrophosphate method in the laboratory. Soil erodibility was assessed by sieving surface particles and by using the particle distribution parameter (particles < 0.84 mm).

Of the 120 soil profiles, 64% were classified as Humisols and 32% as Mesisols. Concerning depth, 38 soil profiles were of the terric sub-group. Furthermore, the latter were generally located near the peatland boundaries. 71% of soil profiles contained limnic material unsuitable for agriculture with a mean thickness of 59.5 cm at various depths between 27 cm and 392 cm. Soils presenting growth limitations were characterised by a shallower soil profile above an impervious layer and were not related to Great Group distribution.

Measurement-based tools to quantify soil nitrogen supply and verify right rate recommendations

D.L. Burton, Department of Plant, Food and Environmental Sciences, Dalhousie University.

Improving nitrogen use efficiency in crop production is an economic and environmental priority. The Government of Canada has identified the goal to reduce N_2O emissions from the use of nitrogen fertilizer. Implementation of the 4R Nitrogen Management has the potential to realize improved nitrogen use efficiency and reduce environmental impacts on air (NH_3 and N_2O) and water (NO_3^-). Here we will report on a measurement-based approach that uses measures of soil nitrogen supply, nitrate exposure and residual soil nitrogen to determine site-specific Right Rates of N fertilizer application and document success of 4R implementation in limiting the potential for nitrogen impacts on the environment. The measurement of soil nitrogen supply, and consideration of climatic impacts, allows for inclusion of N mineralization in right rate N fertilizer determination. The measurement of nitrate exposure quantifies the potential for N_2O emissions associated with the accumulation of nitrate in the soil during the growing season. Residual soil nitrate quantifies the amount of nitrate remaining in the soil following harvest, nitrate that has a high probability of being lost to air or water over the non-growing season.

Use of Low Fertilizer ^{15}N Enrichment for Quantifying Nitrogen Competition and Fertilizer Use Efficiency in Intercrops

Eric Bremer, Western Ag Innovations, Saskatoon, SK. ericbremer@westernag.ca
Ben Ellert, Agriculture and Agri-Food Canada, Lethbridge, AB.
Doon Pauly, formerly with Alberta Agriculture and Forestry, Lethbridge, AB

Intercropping of pulse and oilseed crops has the potential to increase N efficiency and overall crop productivity due to synergistic N requirements. To evaluate crop competition for N under intercropping, we applied UAN solution with low ^{15}N enrichment to whole plots through a drip irrigation system: 50 kg N/ha at $\delta^{15}N$ of 215 was applied to plot area of 14 m^2 in 20 L of water at rate of 0.25 L/emitter. Factors evaluated were cropping system (pea and lentil intercropped with canola or yellow mustard) and application timing (0 vs. 5 weeks after planting) at dryland and irrigated sites over three years. For monocrop systems, crop uptake of ^{15}N was similar for pea and oilseed crops (55%) but lower for lentil (29%). When lentil was intercropped, ^{15}N uptake of lentil declined by an average of 75% while the ^{15}N uptake of the associated oilseed only declined by an average of 25%. When pea was intercropped, ^{15}N uptake of pea declined by 80% when intercropped with canola (2018) and by 54% when intercropped with mustard (2019 and 2020). Timing of ^{15}N application did not appreciably impact crop ^{15}N uptake. Intercropped pulse crops were more dependent on biological N_2 fixation, but fixed less N. Total crop productivity increased by an average of 51% when N supply was strongly limiting oilseed yield and 11% when N was not limiting.

Title: The Impact of Cover Cropping on Soil Nitrogen Availability, Nitrous Oxide Emissions, and Crop Nitrogen Use based on an Irrigated Prairie Cropping System

Olivia Otchere[1], Rich Farrell[2], Melissa Arcand[2], Bill Biligetu[1], Yvonne Lawley[3], and Kate Congreves[1]

[1]Department of Plant Sciences, [2]Department of Soil Science, University of Saskatchewan and [3]Department of Plant Science, University of Manitoba

Correspondence: **kate.congreves@usask.ca**

Cover cropping has been recognized as a key strategy to regulate soil nitrogen (N) availability and reduce N losses. However, the short and dry growing season in Prairie Canada makes it challenging to successfully integrate cover crops in rotations. Novel research is required to address this research gap by testing the viability of growing cover crops in a prairie field crop rotation, and determine its influence on soil N availability, crop N use, and its potential for reducing N_2O emissions. The experiment was initiated in 2018 on sandy loam soil of a Dark Brown Chernozem of the Asquith association, and compares a 4-year rotation sequence of wheat-canola-potato-pea grown with *vs*. without shoulder-season cover crops (red clover, berseem/oat mix, fall rye and mustard/tillage radish mix, respectively). A short rotation (wheat-canola) and a perennial alfalfa are included as treatment checks. The plots are arranged in a randomized complete block design with four replicates. Crop yield and biomass measurements are collected, as well as cover crop measurements (plant counts, heights, ground cover, aboveground biomass); samples are analyzed for N content to determine cover crop tissue N and crop N use. Soil inorganic N dynamics and nitrous oxide emissions (N_2O) are monitored over growing period to determine cover crop influence on soil N availability and N_2O emissions. Preliminary results show cover crops accumulated biomass ranging from 90-437 kg ha^{-1} and contained 3.9-16.8 kg N ha^{-1}. Cover crops reduced soil inorganic N (SIN) supply rate in fall but increased SIN in spring. Crop yields increased in 2020 when grown with or without cover crops compared to 2019. The cover crops did not impact N use efficiency and we did not find robust evidence that cover crops influenced N_2O emissions.

Rye cover crop improves vegetable crop nitrogen use efficiency and yield in a short-season growing region

Soudeh Farzadfar[1], J. Diane Knight[2] and Kate A. Congreves[1*]

[1]Department of Plant Sciences, University of Saskatchewan, Saskatoon, SK, Canada, S7N 5A8 [2]Department of Soil Science, University of Saskatchewan, Saskatoon, SK, Canada, S7N 5A8

*_Corresponding author_ kate.congreves@usask.ca

Abstract

Cover crops have the potential to immobilize nitrogen (N) that would otherwise be lost before or after the main crop production, leading to improved N management. However, information on how cover crops influence N management in intensive vegetable cropping systems are scarce. This study aimed to determine how an overwintering rye cover crop impacts crop yield and N cycling, for three common prairie vegetable crops. From 2017 to 2019, a broccoli-sweet corn-root crop sequence was tested (in which all crops of rotation were present each year), with each crop type receiving five N fertilizer treatments, ranging from 0 to 300 kg N ha^{-1}. After harvest each year, sub-plots were established with *vs* without a rye cover crop, and the effect on vegetable yield, soil inorganic N, and N use efficiency (NUE) was followed into the subsequent growing season. In most cases, the cover crop increased vegetable crop productivity and N content in the subsequent growing season. The cover crop also lowered soil inorganic N levels at vegetable planting but increased levels at harvest. Vegetable crop NUE indices were frequently improved with *vs* without the cover crop. As for the N fertilizer response, increasing N fertilizer rate did not continually increase vegetable crop productivity and N content. Higher N fertilizer rates increased soil inorganic N levels at vegetable planting and harvest, and often lowered vegetable crop NUE indices. These results demonstrate the importance of adjusting soil N levels to better align with crop needs—and that including a rye cover crop in the vegetable rotation is one method of doing so.

Keywords: Broccoli, Sweet corn, Root crop, Cover crop, Nitrogen use efficiency

Developing a CANB - Reactive N model to simulate nitrogen gas emissions and leaching losses in Canadian agricultural system

Jingyi Yang[a], Craig F. Drury[a], Xueming Yang[a], Keith Reid[a], Devon Worth[b], Shabtai Bittman[c], Raymond Desjardins[b]

[a] Harrow Research and Development Centre, AAFC, 2585 County Road 20, Harrow, Ontario N0R 1G0
[b] Ottawa Research and Development Centre, AAFC, 960 Carling Ave, Ottawa K1A 0C5
[c] Agassiz Research and Development Centre, AAFC, 6947 Highway 7, Agassiz, BC, V0M1A0
(corresponding email: jingyi.yang@canada.ca)

Agriculture, which produces food, fiber and shelter needed for the world's growing population, is a major contributor of reactive N (Nr). However, the increase in Nr is one of leading environmental concerns. A reactive N model (CANBNr) has been developed to estimate residual soil N and N losses from N_2O, NH_3 emissions, and NO_3 leaching across Canada at Soil Landscapes of Canada (SLC) 1:1M polygons resolution. The model accounts for annual N inputs to farmland including fertilizer, manure N, biological N fixation, and atmosphere N deposition. Agricultural system outputs include N uptake by food and feed crops, gaseous losses from NH_3, N_2O and leaching losses from NO_3. The reactive N model (CANBNr) is based on the types of crop grown and their associated land area, number and types of livestock, and soil databases for 3487 SLC polygons from 1981 to 2016. The 2020 version of CANBNr integrates NH_3 emissions from applied fertilizers, stored and applied manures, direct and indirect N_2O emissions from fertilizers, stored and applied manures, bare soil and crop residues. The NH_3 and N_2O data were estimated by specialized AAFC teams. The nitrate leaching module was updated for 1981-2016 based on improved drainage simulations by the soil N model DNDC for SLC polygons. The new CANBNr2020 model estimated reactive N losses by SLC for 27 crops (annual arable crops, forage, alfalfa, improved and unimproved pasture). The SLC results were scaled up to eco-regional, provincial and national scales.

In this presentation, the model structure and key input/output will be presented. Secondly, the linkage between the CANBNr model and its inputs from other data models will be presented at the SLC v3.2 scale, including Census of Agriculture data (crop area and animal numbers), yield data from AAFC, NH_3 and N_2O data from other models & DNDC water balance data. The preliminary RSN results will be illustrated to show the trends of nitrogen use efficiency, reactive N loss (NH_3, N_2O and NO_3) from 1981-2016 at Soil Landscapes of Canada (1:1M) polygon, Eco-regional, provincial and national scales.

Keywords: CANBNr model, Residual soil nitrogen, N_2O emission, NH_3 emission, nitrate leaching, Soil Landscapes of Canada

Influence of soil aggregates on soil nitrogen mineralization and denitrification

Bangwei Zhang[1] (bangwei.zhang@dal.ca), David Burton[1] (dburton@dal.ca), Gordon Price[2] (gprice@dal.ca), Brandon Heung[1] (brandon_heung@dal.ca)
[1] Department of Plant, Food, and Environmental Sciences, Faculty of Agriculture, Dalhousie University
[2] Department of Engineering, Faculty of Agriculture, Dalhousie University

The role of soil structure and aggregation in influencing N dynamics in soils undergoing freeze-thaw cycles is not well understood. Here we examine the effect of freezing and thawing cycles on soil respiration and N dynamics in surface soil (0-15 cm) as influenced by soil structure (whole aggregates / crushed soil) and aggregate size fractions (0-0.25, 0.25-4, and 4-8 mm). Our results indicate that microbial metabolism (CO_2 respiration) was more limited by environmental conditions (temperature) than by the substrate availability. Crushing of aggregates altered structural characteristics and caused changes in substrate solubilization and / or microbial utilization of substrates during freezing and thawing. Successive freeze-thaw cycles significantly enhanced soil N mineralization in structurally intact soils from 1.79 to 3.75 $mg \cdot kg^{-1} \cdot soil$, while when aggregates were crushed was not significant. Also, the impact of freeze-thaw on soil respiration and N mineralization was greatest in medium size aggregates (0.25-4mm). The respiration of medium size aggregates increased considerably by 42.5%. Freezing and thawing did not influence the denitrification of the whole soil, but enhanced denitrification in soils where aggregates were crushed by about 3 times. Freezing and thawing increased denitrification in aggregates in each of the three aggregate size fractions by an average of 1.63 $mg \cdot kg^{-1} \cdot soil$, which is about 2.5 times of the original.

Keywords:
Nitrogen mineralization, denitrification, freezing and thawing cycles, soil structure, aggregates.

Evaluation of Seasonal Dynamics of Soil Macro-Nutrients and Corn Nutrient Uptake in Fields Amended with Three Types of Municipal Biosolids

Zheya Lin[a], G.W. Price[a], David L. Burton[b], and O.Grant Clark[c]*

[a]*Department of Engineering, Dalhousie University Faculty of Agriculture, PO Box 550, Truro, NS, B2N 5E3, Canada*

[b]*Department of Plant, Food, and Environmental Sciences, Dalhousie University Faculty of Agriculture, PO Box 550, Truro, NS, B2N 5E3, Canada*

[c]*Department of Bioresource Engineering, McGill University, Macdonald Stewart Building, 21111LakeshoreRoad, Ste-Anne-de-Bellevue, QC, H9X 3V9, Canada*

* Corresponding author. *E-mail address:* gprice@dal.ca (G.W. Price).

Abstract

Biosolids are a nutrient-rich by-product of wastewater treatment plants, containing a significant amount of nitrogen (N) and phosphorus (P). Land application of biosolids for crop fertility is an alternative approach to dispose of the waste and improve and maintain productive soils. The use of these amendments can partially support plant growth, thus minimizing reliance on chemical fertilizers. Field-based experiments were conducted to examine the effects of three municipal biosolids (composted, liquid mesophilic anaerobic digestion, and alkaline stabilization) on soil nutrient dynamics, specifically N, P, and K, applied over three years in Nova Scotia. In this study, a total of 15 treatments were evaluated based on management associated with the surface vs. incorporation of biosolids and the application of biosolids with urea supplementation. Crop yield and plant nutrient uptake were also examined to develop a nutrient use efficiency index. The results indicated the application of municipal biosolids increases nutrient availability. Alkaline treated biosolids increased soil pH (1 to 1.5 pH units) in acidic agricultural soils. Biosolids incorporation had greater effects on soil mineral N, crop yield, and N uptake than surface spreading, but no management practices or rate effects were observed for Mehlich 3 extractable P and K and plant P and K uptake. Crop response was highly dependent on N availability and weather conditions, with alkaline treated biosolids > liquid mesophilic anaerobic digested biosolids > biosolids composting, showing the greatest response.

Long-term shifts in litter deposition alters the molecular biogeochemistry of soil organic matter in temperate forests

Myrna J. Simpson (email: myrna.simpson@utoronto.ca)
Environmental NMR Centre, Department of Physical and Environmental Sciences, University of Toronto Scarborough, Toronto, Ontario M1C1A4

Global environmental change is altering the rate and direction of the biogeochemical cycling of carbon which in turn alters the stabilization and destabilization of soil organic matter and soil carbon storage. Soil organic matter composition is complex and unravelling its biogeochemistry requires the development and use of sophisticated analytical approaches. An integrative molecular biogeochemistry approach was used to study how above- and below-ground inputs and removals altered soil carbon and organic matter composition after 20 years in three temperate forests (Bousson, PA; Harvard, MA; and HJ Andrews; OR); these forests have different litter qualities and soil types. The molecular-level approach isolates and quantifies plant- and microbial-derived compounds using mass spectrometry and nuclear magnetic resonance approaches. Interestingly, added litter resulted in soil priming across all three sites and the addition of high quality litter encouraged the production of microbial-derived lipids, suggesting that high quality litter addition increases microbial-derived contributions to soil organic matter. Radiocarbon analysis showed that both litter additions and exclusions changed the relative turnover time of soil organic matter at all three forests. This synthesis will compare ecosystem properties to identify the long-term controls on soil organic matter biogeochemistry in temperate forests.

Clay type selects for distinct bacterial and fungal communities with consequences for soil organic matter chemistry and quantity

Cynthia M. Kallenbach[1], Gregory Pec[2], Serita D. Frey[3], and A. Stuart Grandy[3]

[1]Department of Natural Resource Sciences, McGill University

[2]Department of Biology, University of Nebraska

[3]Department of Natural Resources and the Environment, University of New Hampshire

Clay minerals may impact soil microbial communities and how microbial communities process carbon (C) inputs with uncertain consequences for C accumulation on mineral surfaces, especially C derived from microbial compounds. Differences in microbial communities may thus potentially override the influences of mineral sorption capacity in determining soil organic C (SOC) accumulation. We hypothesized that 2:1 and 1:1 clays would select for taxonomically and functionally distinct bacterial and fungal communities and would be associated with differences in soil organic matter (SOM) chemistry and quantity between the clay types. We used model soils in a 15-month lab incubation that consisted of either a 1:1 kaolinite (lower reactivity) or 2:1 montmorillonite (higher reactivity) clay-sand mixture. Each clay type was initially C- and microbe-free and inoculated with a natural microbial community. Incubations received weekly additions of glucose and inorganic nutrient substrates. At 9 and 15 months, we performed bacterial and fungal amplicon DNA sequencing to compare microbial community structure. We also examined microbial substrate use efficiency and extracellular enzyme activities, as well as SOM chemistry and amount of new SOC accumulated. Bacterial and fungal community structure was different by clay type and time ($p < 0.05$), with >15 indicator taxa. For example, some of the most abundant taxa (e.g. *Eurotiales*) in kaolinite were not present or <1% within montmorillonite. Kaolinite soil was overall less diverse and had smaller and fewer overlapping niches based on co-occurrence network analysis. Despite lower diversity, Kaolinite soil exhibited on average higher enzyme activities, higher substrate use efficiency, and more SOC and SOM compound richness compared to montmorillonite ($p < 0.05$). Bacteria and fungal richness explained 24% and 60% of variability in substrate use efficiency and enzyme activity respectively, which both decreased with increasing fungal and bacterial richness. In our model systems we find that clay type is a strong selective force on microbial community composition and substrate use that may explain unexpectedly higher SOC accumulation in less reactive 1:1 clay.

Orchards and vineyards as soil carbon 'hotspots' in the Okanagan Valley, BC

Kirsten D., Hannam[1], Andrew, J. Midwood[2], Tirhas Gebretsadikan[2], Melanie D. Jones[2]
[1]Agriculture & Agri-Food Canada, Summerland, BC
[2]University of British Columbia – Okanagan, Kelowna, BC

Increased soil C is associated with numerous co-benefits, such as improved plant productivity and nutrient availability, and mitigation of rising atmospheric CO_2 levels. Many conventional agricultural practices lead to a loss of soil carbon (C), but this is not universal. In semi-arid regions, for example, cultivation of irrigated, woody perennial crops can promote soil C capture. We aimed to identify the mechanisms by which C is retained in the soils of woody perennial cropping systems in the semi-arid Okanagan Valley of south-central British Columbia, and determine any limits to increased soil C capture. We analyzed the C and natural abundance ^{13}C concentrations of the particulate organic matter (POM) and mineral associated organic matter (MAOM) fractions in soils from eight drip-irrigated apple orchards and vineyards, eight micro-sprinkler-irrigated apple and cherry orchards, and eight non-cultivated areas with native grassland vegetation. We found that several decades of woody perennial crop production had approximately doubled the average soil C concentration relative to non-cultivated soils (from 10.1± 1.48 g C kg^{-1} to 20.1 ± 0.96 g C kg^{-1} at 0-15 cm). Most of this C was associated with POM. Within woody perennial cropping systems, soil POM contents were greatest in cherry orchards and smallest in vineyards. Although the MAOM fraction accounted for a smaller fraction of the total soil C pool, woody perennial crop production increased MAOM concentrations by > 150%; there were no differences in effect size among cropping systems. MAOM and POM also had markedly different $\delta^{13}C$ values: MAOM was more ^{13}C-rich than POM. Woody perennial crop production caused both the POM and MAOM fractions to become depleted in ^{13}C relative to non-cultivated soils. We concluded that the soils in this region responded to irrigated woody perennial crop production by retaining C within both the POM and MAOM fractions.

Quantification of soil losses due to wind erosion in Montérégie-Ouest (Québec)

1,*Andrés Felipe Silva Dimaté, 2Jean Caron, 3Alain Rousseau, 4Daniel Campbell

1 PhD student in Sols et Environnement, Université Laval, Québec, Qc, Canada.

2 PhD, Professor, Université Laval, Québec, Canada

3 PhD, Professor, Institut National de Recherche Scientifique (INRS), Québec, Canada

4 PhD, Professor, Laurentian University, Grand Sudbury, On, Canada

*Corresponding author. E-mail address: afsid@ulaval.ca (A.F. Silva)

Organic soils in the Montérégie-Ouest region are important for agricultural vegetable production in Quebec. However, these soils are threatened by wind erosion provoked by strong winds blowing across the region. The aim of this study was to estimate soil loss and horizontal dust flux form wind erosion prevailing in cultivated fields. Starting in the summer of 2019, two sites of approximately one hectare were established. Site 1 was cultivated as usual and site 2 left bare. With no cultivation. Weather stations measured wind speed and wind direction at each site. Horizontal dust fluxes were measured by thirty-two Modified Wilson and Cooke (MWAC) sediment catchers randomly placed in the plots at four height between 0.1 et 0.85 m. Four dust traps measured the deposition of airborne particles at 1.5 m height on each site. Preliminary results suggest that spring was the time of the year when fields were the most at risk from wind erosion, during which net soil losses were 2.18 tons at site 1 and 12.77 tons at site 2. However, additional measurements of surface level changes suggest that losses at Site 1 were as high as 62.5 tons during this measurement period. Thus, although the measurements identified the most critical periods, losses may be underestimated due to lack of knowledge of the trapping efficiency of the MWAC catchers installed on the fields and due to a lack of measurements of the real pathways and dominating process of particle transport, such as surface creep and suspension. Measurement of these pathways is necessary to better estimate soil losses due to wind erosion in the Montérégie-Ouest region.

KEY WORDS: Wind erosion, organic soils, dust flux, soil losses

Distribution of Chernozemic Great Groups and Carbon Content across an elevation gradient of a Semiarid Grassland

Alex Kramer[1], Maja Krzic[1], Brian Wallace[2]

[1]Faculty of Land and Food Systems, The University of British Columbia, Vancouver, British Columbia; [2]Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Kamloops, British Columbia.

In 1961, soil and plant communities were examined across an elevation gradient of a grassland steppe ecosystem in the southern interior of British Columbia. Three distinct zones were classified according to vegetation community and Chernozemic great groups. These zones were differentiated by an increase in elevation from 350 to 950 m, a corresponding 6-fold increase in soil organic carbon (SOC) (1.3 to 8.1% C) and sharp differences in effective moisture. This approach created the standard to which all other grassland ecosystems are classified in this region. Since 1961, this grassland has undergone degradation and subsequent recovery due to improved grazing management and therefore needs to be reassessed.

The objective of our study was to determine topographic, microclimactic and soil variables that affect the distribution of Chernozemic great groups and associated plant communities in the same grassland ecosystem that was evaluated in 1961. In 2019, soil total, organic, and inorganic C at 0-30 cm depth and plant species composition were examined. In addition, boundaries of the Brown, Dark Brown and Black Chernozemic great groups were re-examined relative to 1961. Measurements were done at South facing slopes at specific topographic positions every 25-m in elevation. The sequence of vegetation communities across this grassland has changed relative to 1961. The lower and middle grasslands, which used to be distinct, have become a continuation of the same bunchgrass-sagebrush community as a result of an improved livestock grazing system since 1961. Similarly, soil C content only marginally increases from the lower to middle grasslands. Despite this, several other parameters are still able to distinguish the Brown, Dark Brown and Black Chernozemic great group across this area. Namely, an increase in average precipitation from 96 mm at low elevation to 278 mm at high elevation when averaged for 2017-2019 growing season was still present and accompanied with the air temperature decrease of 3.8°C over the same elevation gradient. Furthermore, this was also accompanied by a 7-fold increase in SOC at the 0-15 cm depth across the gradient (0.9% to 6.8%) and a 3-fold increase in C stock (2.87 kg/m2 to 8.51 kg/m2), indicating that elevation remains the primary factor that affects Chernozemic great group distribution across this landscape due to its effect on effective precipitation and air temperature.

Restoring cultivated organic soils through organic amendments.

Bulot, D, J. Dessureault-Rompré D, K. Bourdon and. J. Caron.

Organic soils are encountered at many locations across Canada and they are used for intensive production of vegetables mainly in the Toronto and Montréal area. Up to 80% of the Canadian lettuce production is grown on the soils. Such soils face important degradation problems due to wind erosion and organic matter decomposition, where soil losses simply due to decomposition reaches about 15 tons per hectare per year. Previous work has shown that amending the soil annually at this same 15 T/ha/y with willow and miscanthus can compensate for this decomposition, maintaining the carbon amount, while not creating major nitrogen immobilization for commonly grown crops like leafy greens. A long-term greenhouse study was performed on field collected 60-cm high organic soil columns amended with different biomasses at different rates, incubated at 22^{o} C and regularly irrigated once they reached a water potential at -15 kPa at the 15-cm depth. The objective was to determine the effect of biomass applications on soil column height, a critical parameter to maintain good drainage conditions and good water and air retention properties in the top horizons enhancing crop productivity The results show that after 3.5 years of incubation with regular amendments (equivalent to 10 years in degree days in the field) made at an equivalent rate of 12 to 15 T/ha/y were enough to maintain a constant columns height. This may be high enough to maintain the high productivity of this soil. An application made at a higher rate (30 T/ha/y) would allow a gain in height but with a high risk of nitrogen immobilization. Additional studies are ongoing to confirm the validity of these conclusions at the field scale.

Testing manganese limitations as the basis for enhanced forest soil carbon sequestration

JM Kranabetter[1]*, TJ Philpott[2], DE Dunn[3]

[1]British Columbia Ministry of Forests, Lands and Natural Resource Operations

P.O. Box 9536, Stn Prov Govt, Victoria, B.C., Canada V8W 9C4

Email: Marty.Kranabetter@gov.bc.ca, Tel: 1 778 698-9260

*corresponding author

[2]British Columbia Ministry of Forests, Lands and Natural Resource Operations

200-640 Borland Street, Williams Lake, B.C., Canada V2G 4T1

[3]Natural Resources Canada, Pacific Forestry Centre

506 Burnside Road West, Victoria, B.C., Canada V8Z 1M5

Manganese (Mn) has been identified as a regulatory bottleneck in the accumulation of humus because of its role as a enzymatic co-factor in the breakdown of recalcitrant C by Mn-peroxidase (MnP). We tested this abiotic limit on decay via contrasting soils along a podzolization gradient of coastal British Columbia, where an inverse exponential relationship between soil organic carbon (SOC) and exchangeable Mn had been observed. Moderately weathered soils (Brunisols) had an average 3.6-fold increase in MnP activity within the upper soil profile in comparison to highly weathered Podzols. An ordination of the Agaricomycete fungal community, which are responsible for MnP production in soils, confirmed significant differences in assemblages across soil types for saprotrophic fungi, particularly species within the Agaricales, Trechisporales and Auriculariales. Ectomycorrhizal fungi of *Pseudotsuga menziesii* were equally aligned with soil type and select taxa more abundant on Brunisols may have supplemented MnP activity. A laboratory incubation with an Mn amendment produced significant interactions in MnP activity by soil type. Surprisingly, MnP activity of both Brunisol substrates declined substantially with an amendment (-56% and -40% for forest floor and mineral soil, respectively), in contrast to Podzols (-30% and +26%, respectively). This inhibitory response was linked to considerable uptake of the amendment, and underscores how Mn^{2+} operates directly on fungi as a regulator of *mnp* transcription for MnP production. Our study highlights a new perspective concerning the abiotic drivers underpinning the large, expansive soil C stocks across perhumid temperate rainforests of the Pacific Northwest.

Agriculture in the Boreal Forest: Understanding the Impact of Land Use Change on Soil Organic Carbon for Developing Sustainable Community Food Systems

Bysouth, D.1*, Turetsky, M.R.2, Spring, A.3
1 University of Guelph – *corresponding author (dbysouth@uoguelph.ca), 2 University of Colorado Boulder, 3 Wilfrid Laurier University

Climate change is causing rapid warming at northern high latitudes and disproportionately affecting ecosystem services that northern communities rely upon. In Canada's Northwest Territories (NWT), climate change is impacting the access and availability of traditional foods that are critical for community health and well-being. With climate change potentially expanding the envelope of suitable agricultural land northward, many communities in the NWT are evaluating including agriculture in their food systems. However, the conversion of boreal forest to agriculture may degrade the organic matter rich soils that characterize the region, resulting in large carbon losses to the atmosphere and the depletion of existing ecosystem services associated with the accumulation of soil organic matter. Here, we first summarize the results of 30 publications that address land use change from boreal forest to agriculture, with the goal of understanding the magnitude and drivers of soil organic carbon stock changes with time-sinceland use change. Results from the literature synthesis show that conversion of boreal forest to agriculture can result in up to ~57% of existing soil organic carbon stocks being lost 30 years after land use change occurs. Secondly, we also present community scale soil data, from 192 collected soil cores, assessing variation in soil organic matter in relation to a suite of soil fertility metrics targeted to areas the communities are interested in cultivating. Our field soil carbon measurements in collaboration with the partnered NWT communities show that land use conversions associated with agricultural development could translate to carbon losses ranging from 2.7-11.4 kg C/m2 depending on the type of soil, management practices, and type of land use change associated with cultivation. These results highlight the importance of managing soil organic matter in northern agricultural systems and can be used to emphasize the need for new community scale data relating to agricultural land use change in boreal soils. Through the collection of this data, we hope to provide northern communities with a more robust, community scale product that will allow them to make informed land use decisions relating to the cultivation of crops and the minimization of soil organic matter losses while maintaining the culturally important traditional food system.

Alberta's Approach for Teaching Pedology Outside University Programs

Konstantin Dlusskiy, PhD, P.Ag.
Paragon Soil and Environmental Consulting Inc.
kdlusskiy@paragonsoil.com

Deficiencies in pedology education in Canada have been identified as a limited number of courses in soil science, insufficient field-based training, and lack of advanced courses in pedology (Diochon et al 2017, Masse et al 2019). While the options for professional development in pedology are limited, a lack of information about available opportunities also seems to be an underestimated issue. This presentation reviews the current situation in Alberta, where several options for upgrading soil science knowledge have been offered with the last 10 years, beyond on-the-job training:

1. The University of Alberta Faculty of Extension offers six advanced 3-credit courses. The courses are offered without prerequisites and can be taken as stand-alone product, or as a part of a certificate program. For example, the "Certificate in Soil Science" program includes four of those six courses. The courses are recognized by the Alberta Institute of Agrologists (AIA), and can be applied toward professional designations in Agrology. Some of the courses are being delivered online during the COVID-19 pandemic.
2. The Alberta Soils Tour organized by the Alberta Soil Science Workshop is a biennial 2- to 3-day field tour organized by volunteers. Recognizing the gap in pedology education, the emphasis was shifted from edaphology to pedology since 2016. The Tour is recognized by the AIA as professional development (Continuing Competency Program) hours only.
3. Public education by private companies became available recently as Paragon Soil and Environmental Consulting Inc. has offered two online courses to external students. The 16-hour courses became an option for professional development in the field of pedology that suits student needs in the COVID-19 pandemic. The courses are recognized by the AIA as professional development.

Generally, junior pedologists have multiple options to advance their soil education, even during COVID-19, but need to search for information via universities, professional societies, and private educators.

An On-line Oral Laboratory Final in Identification of Saskatchewan Plants and Soils

T. Yates*, M. Reed*, and A. Muller**

*University of Saskatchewan, Department of Soil Science, Saskatoon, SK

**University of Saskatchewan, Department of Plant Sciences, Saskatoon, SK

Email for the corresponding author: Tom Yates (tom.yates@usask.ca)

ABSTRACT

Experiential learning is key to the delivery of soil science skill and knowledge. Thus, delivery of courses in soil science, environmental science, and resource science has been especially disrupted due to the impact of Covid-19. Adapting lectures to on-line formats has not been without its problems and limitations, but considering the typical in-person lecture experience, has not been difficult to simulate virtually, and student response would indicate that it has been contextually successful. However, laboratory experiences have been difficult to re-create and in many cases have been completely reimagined or eliminated altogether. For a 200 level course in plant identification, and soil description/classification we chose to retain the laboratory section and attempt to recreate the experience on-line. Existing laboratory assignments were modified, and in some cases simplified to address the challenge faced by students in learning to identify and classify from photos of soils and plants, instead of real examples normally provided. Emphasis was placed on learning and applying knowledge, and less on providing a comprehensive study of common plant species and the range of soil classes common to Saskatchewan. This shift in delivery of the laboratory experience and re-prioritization of learning outcomes behooved a significant change to the format of the final laboratory exam. Considering the changes to teaching imposed by Covid-19, it was decided that an oral exam, something unique to this course and possibly similar courses, could be designed to allow students to demonstrate their ability to apply the knowledge acquired through the lab assignments. This presentation will describe the format of this oral exam and reflections on its delivery.

Mobilizing soil science research knowledge with the SOILS AT GUELPH initiative

Cameron M. Ogilvie*, Kari E. Dunfield, Claudia Wagner-Riddle, and Laura L. Van Eerd
School of Environmental Sciences, University of Guelph. Guelph, ON N1G 2W1.
Corresponding author: cogilvie@uoguelph.ca
*Presenting author

There has been a surge of interest in soil on an international, national, and provincial level: the Food & Agriculture Organization of the United Nations named 2015 the International Year of Soils; Canadian Senator Rob Black has been in the media recently calling for a nation-wide soil study; in 2016 a white paper was released from Ontario's Environmental Commissioner on "Putting Soil Health First". On World Soil Day in 2018, a $500,000 donation from Lillie Ann Morris, Bob and Moira Kerr, and Glacier Farm Media was made to support soil health outreach from the Ontario Agricultural College at the University of Guelph. The SOILS AT GUELPH initiative was formed – a research knowledge mobilization initiative with the mission to advance sustainable soil management in Ontario by bridging gaps between researchers, farmers, industry, government, and the public. The initiative's core activities encompass developing research content in a variety of forms for different audiences (ex. plain language summaries, fact sheets, presentations), hosting soil health knowledge mobilization events, and supporting the existing network of soil health champions in Ontario. A website was developed to promote the people and publications connected with ongoing research; in 2021, the website received 12,400 page views from over 4,000 users. SOILS AT GUELPH has made inroads with the agricultural community on Twitter, gathering over 1,500 followers to date. Over the past year, the initiative and its members have virtually connected with over 1,100 people through plot tours, educational modules, workshops, public lectures, podcasts, and research presentations, and have been featured in over a dozen popular press articles. Early evaluations of these activities within the context of other Ontario soil initiatives will be presented along with ideas for refocusing the initiative in the coming years.

3D Soil Monoliths for Virtual Classrooms

Authors: Maja Krzic[1,2], Sharon Hu[3], Michal Suchanek[4], Lewis Fausak[2], Hanson Lee[5], Tianyi (Vera) Bao[6], and Suzie Lavallee[1]

Affiliations:

1. Faculty of Forestry, University of British Columbia, Vancouver, BC
2. Faculty of Land and Food Systems, University of British Columbia, Vancouver, BC
3. UBC IT, University of British Columbia, Vancouver, BC
4. 778 Labs, Vancouver, BC
5. Faculty of Science University of British Columbia, Vancouver, BC
6. Faculty of Arts, University of British Columbia, Vancouver, BC

Soil classification and understanding pedological processes are essential components of a soil science curriculum as they are critical for students to begin to understand how soil is formed and how soil interacts with the environment. Since the COVID-19 pandemic has resulted in the majority of soil science courses moving to online platforms, students could not receive in-person instruction regarding soil description and classification through either field trips or examination of soil monoliths in the classroom. This creates challenges in skill development in these key areas of soil science. To address these challenges and to show the potential benefits of incorporating 3D monoliths into the curriculum, we created 3D models for each of the 197 soil monoliths in UBC's collection. This was done using photogrammetry and multiple highresolution photos. In addition, several 3D monoliths were also supplemented with (i) a 360º photo of typical landscapes in which that soil would be found in and (ii) text annotations containing descriptions of key soil properties. These 3D models are hosted on the platform called Sketchfab and are also linked to https://monoliths.soilweb.ca/. They can also be embedded in an online learning management system (e.g. Canvas, Moodle, Blackboard) to be viewed during synchronous classes or asynchronously by students.

Lessons Learned Teaching a Large Online Introductory Soil Science Course during the COVID-19 Pandemic: Instructor Perspectives

Sandra Brown1* and Maja Krzic2
1Faculty of Land and Food Systems, University of British Columbia, 2357 Main Mall, Vancouver, BC V6T 1Z4
2Faculty of Land and Food Systems / Faculty of Forestry, University of British Columbia, 2357 Main Mall, Vancouver, BC V6T 1Z4
*Corresponding author: email: sandra.brown@ubc.ca

ABSTRACT

Due to the COVID-19 pandemic we were confronted with the transition of a large on-campus introductory soil science course, into the online setting. This created several challenges such as, providing meaningful learning experiences to engage first and second year students, and re-structuring course content for the online environment. The objective of our study is to document the transition from on-campus to online teaching and learning, through the consolidation of existing course material and the development of new resources to engage students in an introductory soil science course. The timeframe for preparation has been insufficient to undertake comprehensive course re-design, but opportunities exist to leverage existing online content, incorporate synchronous and asynchronous elements into courses, and build value-added online resources that will have utility beyond the COVID-19 pandemic. For a large introductory science course, a clear structure (such as weekly), which aligns content and assessment with learning outcomes is, in our opinion, fundamental and a critical first step in transitioning to online teaching and learning. Pre-existing course materials, including videos, laboratory manuals and assignments, may require revision to align with learning objectives. A combination of synchronous and asynchronous classes, office hours and virtual laboratories are encouraged to accommodate students' schedules and to enhance student engagement. In our presentation we will compare on-campus, distance education and online blended teaching and learning approaches for the same course, and provide lessons learned that may be applicable to other large introductory science courses. Recognizing the narrow preparation window, judicious change focused on developing resources that provide benefits beyond COVID-19 are endorsed.

Teaching Assistant Perspectives on Student Engagement in Online Labs of an Introductory Soil Science Course

Joe Crudo[1], Fernanda Díaz[1], Trish Hanuszak[1], Raelani Kesler[1], Franco López Campomanes[1], Amy Mays[2], Teresa Porter[1], Lewis Fausak[1], Sandra Brown[1], Maja Krzic[1,2]

[1]Faculty of Land and Food Systems, [2]Faculty of Forestry, University of British Columbia, Vancouver, BC, Unceded xʷməθkʷəy̓əm (Musqueam) Territory

Corresponding author: Raelani Kesler, rkesler@mail.ubc.ca

In March 2020, postsecondary institutions across Canada and around the world experienced an abrupt transition of teaching and learning to an online format due to the COVID-19 pandemic. This rapid transition to the online setting posed numerous challenges, especially in courses that include a lab component. The objective of our presentation is to outline Teaching Assistant (TA) perspectives on challenges and advantages of offering a large introductory soil science course (with ~300 students) in an online setting. At the University of British Columbia, the Introduction to Soil Science course is required by several majors in the Faculties of Forestry, Land and Food Systems, and Science. Offering this course online has been particularly challenging for those first- and second-year students who are new to the university setting. In 2021, the introductory soil science course has been taught by a team of 2 instructors, 7 TAs, and 1 education/research technician, through weekly synchronous classes and labs and asynchronous learning through the use of the online resources. One of the main challenges of online education during the pandemic has been the elimination of formative feedback from students, since course TAs and instructors often cannot see students' faces or students' work in lab and/or field settings. We aimed for student engagement not just with the course content, but with other students and us, as TAs. We sought creative means of fostering group identities within lab groups, finding new ways of checking in with student learning, and centering student voices during lab time. For example, we used icebreakers (soil bingo, how are you feeling today on the scale of cats), rebus puzzles, naming lab sections, and even developed lab flags and banners. We personalized our teaching approach through sharing our backgrounds or showing our pets and household plants. We included numerous interactive learning activities to the online labs, such as hand texturing with backyard soil and establishing a competition among students regarding the longest worm rolled using soil. Some of those activities will be highlighted during our presentation.

Power of Soil: An Agenda for Change to Benefit Canada's Farmers and Climate Resilience

Paul Smith (Paul Smith and Associates paul@paulsmith.work), Alice Feuillet (Équiterre), Tom Bowers (Greenbelt Foundation)

Canada's governments have had soil and water conservation policies for decades, yet adoption of soil health practices remains modest. Canada spends far less on agri-environmental programs than the US and Europe and lacks extensive social science and extension systems. Significant change is needed to improve soil health and mitigate and adapt to climate change.

Through review of science, social science and policy research, we: 1) identify key soil health practices and summarize their benefits and limitations; 2) summarize knowledge on barriers to adoption of soil health practices; 3) analyze climate and agri-environmental policy in Canada, and; 4) identify innovative policy approaches that could increase soil health practice adoption.

Recommendations:

1. *Prioritize Soil Health:* Make soil health a priority in agricultural policy; Develop a National Soil Health Strategy; Strengthen collaboration among government, farm groups, industry, and partners; Integrate soil health initiatives into climate policies.
2. *Enhance Soil Health Learning:* Create a national soil health knowledge network; Develop business case for soil health; Support key soil health practices; Soil health training for advisors and farmers; A national soil health check-up tool; Build capacity for on-farm demonstration; Enhance farmer-to-farmer learning; Enhance public sector extension; National reporting on soil health.
3. *Incentivize Soil Health*: Increase overall funding for soil health; Fund simple, low risk projects; Reduce the risk of innovation; Use greenhouse gas offset protocols to fund soil health.
4. *Conserve Agricultural Land and Natural Areas*: Develop program to conserve vulnerable / degraded lands; Reduce conversion of perennial forage lands to annual cropland.

Implementation of the recommendations would be a fundamental shift in direction in agri-environmental policy, while helping the long-term viability of agriculture and climate resilience.

Phosphorus losses from Canadian agricultural land over three decades: Results from the updated Indicator of Risk of Water Contamination by Phosphorus (IROWC-P)

Keith Reid, Agriculture and Agri Food Canada (keith.reid@canada.ca)

Phosphorus (P) losses from agricultural land have been identified as a key driver of freshwater eutrophication. Public interest has been high with increasing incidence of harmful and nuisance algae blooms in major lakes like Lake Erie, Lake Winnipeg and Mississquoi Bay on Lake Champlain, as well as many smaller lakes and reservoirs. Understanding the spatial and temporal patterns in P losses are crucial for directing policy responses and investing wisely in mitigation efforts. The IROWC-P model has been extensively revised and updated to incorporate recent knowledge advancements in P source and transport, including:

- Improved allocation of manure and fertilizer P to predict P accumulation patterns
- Explicit partitioning of P transport into surface and subsurface runoff
- Accounting for incidental losses of dissolved P from manure and fertilizer applications
- Accounting for losses of P from overwintering forages

The spatial patterns of risk of P losses from agricultural land predicted by this revised model will be discussed, as well as the management implications of the P “hot spots” that are identified.

Critical phosphorus dilution curve and the phosphorus-nitrogen relationship in potato

Judith Nyiraneza[1], Gilles Bélanger[2], Rim Benjannet[1], Noura Ziadi[2], Athyna Cambouris[2], Keith Fuller[3], Sheldon Hann[4]

1. *Charlottetown Research and Development Centre, Agriculture and Agri-Food Canada, 440 University Avenue, Charlottetown, PE, C1A 4N6, Canada.*
2. *Quebec Research and Development Centre, Agriculture and Agri-Food Canada, 2560 Hochelaga Boulevard, Qu´ebec, QC, G1V 2J3, Canada.*
3 *Kentville Research and Development Centre, Agriculture and Agri-Food Canada, 32 Main Street, Kentville, NS, B4N 1J5, Canada.*
4 *Fredericton Research and Development Centre, Agriculture and Agri-Food Canada, 850 Lincoln Road, P.O. Box 20280, Fredericton, NB, E3B 4Z7, Canada.*

Besides nitrogen (N), phosphorus (P) is the most limiting nutrient for potato growth and P acquisition and utilization is affected by the N supply. Estimating accurately the P nutrition status is critical from economic and environmental standpoints. Our objectives were to (i) compare a critical P (Pc) curve based on the biomass (DM) of the whole plant (vines + tubers) with those recently developed in Argentina (Zamuner et al., 2016, $Pc = 3.92 \times DM^{-0.30}$) and Colombia (Gómez et al., 2016, $Pc = 5.23 \times DM^{-0.19}$); (ii) analyze P dilution in vines and tubers, and to develop Pc curves for vines and tubers; and (iii) analyze the relationship between N and P concentrations in vine, tuber, and total biomass along with the changes in the N:P ratio with increasing biomass. Five P rates up to 240 kg P_2O_5 ha^{-1} were applied to potatoes on soils located in four Canadian provinces from 2016 to 2018 for a total of 11 site-years. Vine, tuber, and total biomass, and N and P concentrations were measured weekly on five dates starting 50 days after planting, and tuber yield was measured at harvest. The Pc curve in total biomass ($Pc = 3.57 \times DM^{-0.38}$) was below that developed in Argentina and Colombia. The P and N concentrations of vine, tuber, and total biomass as well as the N:P ratio declined with increasing biomass. and Pc curves were developed for vines ($Pc = 2.58 \times DM^{-0.20}$) and tubers ($Pc = 2.06 \times DM^{-0.14}$). The P nutrition index (PNI) measured in vines or tubers with their respective Pc curves was significantly related to the PNI in total biomass, implying that P sufficiency before tuber initiation can be estimated by analyzing vines only. Indices to assess P sufficiency along with N and P imbalances in potato vine, tuber, or total biomass represent a promising alternative or a complement to the soil P tests traditionally used for fertilizer recommendations.

Keywords:

Phosphorus dilution curve, Nitrogen, Phosphorus, Phosphorus nutrition index, Potato.

An 11-Year Agronomic, Economic, and Phosphorus Loss Potential Evaluation of Legacy Phosphorus Utilization in a Clay Loam Soil of the Lake Erie Basin

Tiequan Zhang, Yutao Wang, Chin S. Tan and Tom Welacky
Harrow Research and Development Center, Agriculture and Agri-Food Canada, Harrow, ON, Canada
E-mail: Tiequan.Zhang@Canada.Ca

Legacy phosphorus (P) in agricultural soils has become a predominate source contributing to P loadings to Lake Erie since the mid-90s. The use of legacy P in soils can be an ultimate and effective way to mitigate the risk of agricultural P loss and to circumvent potential P rock reserve shortage, while sustaining crop production. A field experiment was conducted to assess the impacts of P draw-down (PDD) (i.e., use of legacy P in soils) on crop yields, P uptake and removal, and soil test P (Olsen P, an agronomic P calibration and environmental soil P risk indicator in the region) under a corn–soybean rotation in a clay loam soil of the Lake Erie Basin, southwestern Ontario, Canada, from 2008 to 2018. Corn and soybean grain yields with PDD were identical to those with continuous P addition (CPA), averaged at 7.7 Mg ha^{-1} for corn and 3.7 Mg ha^{-1} for soybean, over 11 years. Similarly, no significant differences in crop P uptake
and removal were found between PDD and CPA. Compared to CPA, PDD increased net farming income by Canadian dollar (CAD) 104–125 ha^{-1} year^{-1} (i.e., USD 78.5–94.4 ha^{-1} year^{-1}), with savings on P fertilizer materials and associated application costs. Soil P loss risks with PDD reduced, as indicated by soil test P that, in the top layer (0–15 cm), decreased linearly with crop production year at 3.27 mg P kg^{-1} year^{-1} or 16.2 mg P kg^{-1} per 100 kg crop P removal per hectare, while in the lower soil layers, 15–90 cm, it remained unchanged. In comparison, CPA of 50 kg P ha^{-1} sustained soil test P in the entire soil profile, 0–90 cm, over the 11-year period. PDD can be a beneficial management practice utilizing legacy P in soils to achieve both agronomic and economic goals in an environmentally sustainable manner.

Trade-offs in organic nutrient management strategies across mixed vegetable farms in southwest British Columbia

Amy Norgaard[1], DeLisa Lewis[1], Kira Borden[1], Maja Krzic[1,2], Juli Carillo[1], Sean Smukler[1]

[1] Faculty of Land and Food Systems, The University of British Columbia, Vancouver, V6T 1Z4, British Columbia, Canada

[2] Faculty of Forestry, The University of British Columbia, Vancouver, V6T 1Z4, British Columbia, Canada

Corresponding Author:

Amy Norgaard

amy.norgaard@ubc.ca

Nitrogen (N) and phosphorus (P) are essential plant nutrients but when lost from agricultural fields become environmental pollutants. Organic farms strive to maximize crop yields while maintaining core principles of ecology and health, yet yields are typically limited due to challenges with nutrient availability. Organic nutrient sources (composts, manures, cover crops, specialty fertilizers) have difficult-to-predict nutrient supply and the mismatch of the ratio of N to P required by crops compared to ratios of those nutrients in composts and manures results in either a surplus of P or shortage of N (and reduced carbon (C) application). The objective of this study was to evaluate three organic nutrient management strategies in terms of crop yields, input costs, and selected soil properties (permanganate oxidizable carbon - POx-C, post-season available N and P).

Field trials were carried out in 2018 and 2019 on 20 mixed vegetable farms across three regions of southwest British Columbia (lower Fraser Valley, Pemberton Valley, and Vancouver Island). Nutrient strategies evaluated were: *high compost*: compost applied to meet crop N removal, *low compost + N*: compost applied to meet crop P removal plus an organic feather meal fertilizer (12-0-0) to meet crop N removal, and *typical*: the typical nutrient application used by the farmer (varying combinations of composts and/or organic fertilizers, or no application).

Across all three regions, post-season P was 21% higher with *high compost* than with *low compost + N.* In the Fraser Valley in 2019, yields were higher in *high compost* than in *typical*, and input costs were higher in *high compost* and *low compost + N* than *typical*. Principal components analysis showed that *high compost* was also associated with high post-season N when composts are rich in N, which is common in the Fraser Valley (typically poultry manure). With high C to N ratio (C:N) composts, the *low compost + N* strategy was associated with increased yields and POx-C.

While *high compost* can have favourable outcomes on farms with low soil P, the results of this study suggest that *low compost + N* could avoid excess P accumulation in the long term without yield or economic trade-offs. However, reducing P applications while maintaining C inputs remains a challenge when high-P composts and manures are accessible and inexpensive to use. Long-term impacts of reduced C inputs from *low compost + N,* as well as incorporating other C sources (e.g., cover crops), need to be studied further.

Impacts of Precision Cattle Manure Application on Run-off Water Quality

D. Ayanwale[1], J. Elliott[2] and J. Schoenau[1]

[1]Department of Soil Science, University of Saskatchewan, Saskatoon, SK Canada

[2]Environment and Climate Change Canada

Improper application of manure can cause accumulation of soil phosphorus (P) and nitrogen (N), resulting in increased losses in run-off and elevated concentrations in surface water bodies. The objective of this study was to compare the effects of traditional constant rate manure application to variable-rate precision manure application treatments on concentrations of phosphorus and nitrogen in snowmelt run-off water. The research was conducted at the Livestock Forage Center of Excellence Research Facility near Clavet, Sk in a hummocky landscape with Dark Brown Chernozemic soils of Bradwell association. The three treatment zones within the field were set up with three replicate watersheds identified in each zone. The zones were traditional (constant rate) manure application zone, precision (variable-rate with setbacks) manure application zone, and a commercial fertilizer only application zone (control). Variable-rate manure was applied with a variable rate manure applicator using a prescription developed from long-term (16 yr) productivity maps from NDVI satellite imagery. Areas of low productivity (knolls) received higher rates of manure, while areas of high productivity (footslopes and depressions) received reduced rates. Run-off water from individual watersheds was collected in 2018 (spring baseline year), 2019 spring melt before 2019 spring manure application and 2020 spring melt after spring 2019 manure application. Run-off water was analyzed for total dissolved P (TDP), soluble reactive P (SRP), soluble unreactive P (SUP), nitrate-N (NO_3^--N) and ammonium-N (NH_4^+-N) concentrations. Nutrient concentrations in run-off water were significantly higher in the constant manure application rate compared to variable manure rate and commercial fertilizer treatments. Variable-rate application of manure with set back from basin centers may be considered a suitable management practice to limit non-point export of nutrients in spring snowmelt.

Effect of long-term rotation and cover crops on organic matter quality revealed by physical fractionation and soil health measurements.

Authors: Robin M. Bradley1, Laura L. Van Eerd2, Kari E. Dunfield1, Adam W. Gillespie1*

1 School of Environmental Sciences, University of Guelph, Canada

2 School of Environmental Sciences, University of Guelph, Ridgetown Campus, Canada

* Corresponding author e-mail address: agilles@uoguelph.ca (A Gillespie)

Soil organic matter (SOM) is universally cited as one of the most important contributors to a healthy soil because of its positive influence on ecosystem services. There are gaps in our knowledge of how SOM drives improvements in soil health including (i) understanding how SOM composition is affected by Best Management Practices (BMPs) in Ontario and (ii) developing rapid monitoring protocols to track changes of soil health over time. The long-term objective of this study is to understand how soil organic matter composition is affected by BMPs in Ontario. This was determined by (1) analyzing soil health indicators to determine the effect of crop management (tillage, crop rotation, and cover crop) on soil health, and (2) analyzing how soil health indicators differ between particulate organic matter (POM), mineral-adsorbed organic matter (MAOM), and whole-sample organic matter. Soil samples were collected in 2019 from the Long-Term Tillage and Rotation trial located at the University of Guelph's Ridgetown Campus in Ridgetown, ON. Treatments included tillage (no-till or conventional) and crop rotation including cover crops (monoculture corn, monoculture soybeans, corn-soybean, soybean-wheat, soybeanwheat-red clover, corn-soybean-wheat, and corn-soybean-wheat-red clover). Soil cores were collected from a depth of 0-15 cm and homogenized for each plot. A subsample was physically fractionated into POM (>53 μm) and MAOM (<53 μm) and analyzed, along with a whole-sample, for active carbon, aggregate stability, autoclaved citrate extractable soil protein index, total and organic carbon and nitrogen. The results from this project will provide baseline characterizations of SOM chemistry as it relates to soil health and BMPs, and it will provide tools to allow rapid tracing of soil health parameters by relating rapid testing methods to BMP use.

Riparian zones: greenhouse gas emissions from the aquatic component

H. Hundal[1], N.V. Thevathasan[2], N. Chaganti[2], M. Oelbermann[1*]

[1]School of Environment, Resources and Sustainability, University of Waterloo; [2]School of Environmental Sciences, University of Guelph

*Corresponding Author E-mail: moelbermann@uwaterloo.ca

Agricultural intensification in Canada has led to a loss of riparian areas causing the degradation of freshwater aquatic ecosystems (e.g., eutrophication). Rehabilitation/restoration of areas adjacent to freshwater aquatic ecosystems, i.e., the riparian zone, minimizes these effects. Multiple studies have evaluated various aspects of the terrestrial component of riparian zones including vegetation and soil carbon (C) and nutrient cycling and greenhouse gas (GHG) emissions. However, limited information exists on C and nitrogen (N) dynamics from the aquatic component of riparian ecosystems, especially that from rehabilitated riparian forests. Therefore, the objective of this study was to quantify C and N dynamics and GHG emissions in four different riparian zone land-use systems: Undisturbed natural forest with deciduous vegetation (UNFA), undisturbed natural forest with coniferous vegetation (UNFB), ~33 year old rehabilitated riparian forest with deciduous vegetation (RH), and a grassed riparian zone (GRS). Mean CO_2 emissions were not significantly different ($p<0.05$) different among riparian sites ranging from 1.25 g L^{-1} in the UNFA and RH sites, to 1.28 g L^{-1} (GRS) and 1.51 g L^{-1} (UNFB) of CO_2-C respectively. Mean CH_4 emissions were significantly different ($p<0.05$) among riparian sites, with values ranging from 1.11 μg L^{-1} (UNFB), 1.36 μg L^{-1} (UNFA) and 1.81μg L^{-1} (RH) to 2.51 μg L^{-1} (GRS) of CH_4-C. Methane emissions were significantly greater ($p<0.05$) in the GRS site compared to the other riparian sites. Further, CH_4 emissions from the RH site were significantly greater ($p<0.05$) compared to those of the UNFB site. Mean N_2O emissions were significantly different ($p<0.05$) among riparian sites, ranging from 1.00 μg L^{-1} (GRS), 1.23 μg L^{-1} (RH) and 1.37 μg L^{-1} (UNFA) to 3.32 μg L^{-1} (UNFB). Nitrous oxide emissions from the UNFB site were significantly greater ($p<0.05$) compared to all other sites. Additionally, N_2O emissions from UNFA were significantly greater ($p<0.05$) compared to those from the GRS site. Overall, the emissions results showed that GHG emissions from the aquatic component of riparian ecosystems were either lower or similar for the rehabilitated site (RH) compared to either undisturbed natural forests or a grassed riparian zone.

Mitigating nitrous oxide emissions from agricultural soils: an Irish perspective

Murphy P.N.C.[1,2]
[1]School of Agriculture and Food Science, University College Dublin, Belfield, Dublin 4, Ireland;
[2]UCD Earth Institute, University College Dublin, Belfield, Dublin 4, Ireland

Abstract

Agriculture faces increasing demands in terms of sustainability; economic, social, and environmental. Soil N cycling and management lie at the heart of this sustainability challenge, linking the issues of food security and environmental sustainability. The Anthropocene is characterized by a major anthropogenic disturbance of the global N biogeochemical cycle. In particular, soil N_2O emissions are a major contributor to anthropogenic climate change and agriculture is the major source of these emissions globally. This paper will focus on efforts to mitigate N_2O emissions from agricultural soils in Ireland, giving an overview of the management and policy context and providing some examples of mitigation measures such as the use of multispecies grass swards, improved fertilizer N management, and use of nitrification inhibitors. Novel research approaches to developing mitigation measures will also be considered; in particular, the potential for application of N isotope and isotopomer techniques. Potential future directions for research on mitigation measures will be considered.

Nitrogen functional gene abundance as potential indicators for nitrogen cycling under forage legume-grass pasture soils

Tram Thai, Jiancan Liu, Jesse Reimer, Bobbi Helgason and Melissa Arcand.
Department of Soil Science, University of Saskatchewan, Saskatchewan, Canada.

Introduction of legumes such as cicer milkvetch (*Astragalus cicer* L.) and sainfoin (*Onobrychis viciifolia*) in forage pasture is a common practice to improve yields and reduce bloat. How this affects N functional genes, particularly those involved in N_2O emissions, is poorly understood. A field trial was conducted at Termuende Research Farm at Lanigan, SK in a grass-legume stand dominated by brome grass (*Bromus madritensis*) and alfalfa (*Medicago sativa* L.). In 2015, cicer milkvetch and sainfoin were sod-seeded on the existing pasture and were compared to the original pasture composition (control). Soils (0-10 cm) were sampled for microbial analysis in 2017-18. Quantitative real-time polymerase chain reaction (qPCR) was conducted to quantify the abundance of N cycling functional genes (Bacterial/Archaea *amoA*, *nirS/nirK*, *nosZ-I* and *nosZ-II*). Despite no difference in N_2O emissions among legume species, *bacterial amoA* gene abundance was lower in alfalfa-grass and *nosZ-II* gene abundance was higher in cicer milkvetch-grass pasture soils. *NosZ-II* gene abundance, *nosZ-II/nosZ-I* and *nos/nir* were positively associated with soil available N, while *nirS* and *AOB* were positively associated with pH. Our findings suggest that *AOA, AOA*:*AOB* ratio and *nosZ-II* gene abundance might be potential predictors for N cycling under forage legume/grass pasture soils.

Field scale soil freezing variability alters nitrogen cycling functional gene abundance and expression throughout freeze-thaw cycles

Linsey van Koppen1*, Yuanpei (Kean) Gao1, Claudia Wagner-Riddle1, Kari Dunfield1

1School of Environmental Science, University of Guelph, Ontario Canada

*Corresponding author: lvankopp@uoguelph.ca

Agricultural soil is the highest anthropogenic source of the greenhouse gas nitrous oxide (N2O) in Canada. Up to 80% of these emissions from soils are produced during freeze thaw (FT) cycles throughout the non-growing season. With increasing temperatures due to climate change, the frequency of soil FT cycles is projected to rise resulting in uncertainties surrounding soil freezing dynamics. It remains unclear how these potential implications could affect the belowground microbial community that is responsible for N2O flux. Here, we aim to understand variability in soil freezing rates throughout FT cycles in contrasting management practices, and further, identify how this variability will affect the nitrogen cycling microbial community.

A corn-soy-wheat rotation under contrasting management (conventional vs. diverse) was established on 2 large scale field plots at the University of Guelph Research Station in Elora, Ontario, Canada. Plots were fitted with a flux gradient system that measures N2O emissions continuously. Soil was sampled along four transects per plot at four time points between February 20 and March 10, 2020 to capture spring FT cycles. Frozen and thawed soil were collected separately, and liquid nitrogen was applied to the samples to preserve microbial activity prior to DNA and RNA co-extractions. Quantitative real-time PCR was carried out to target key bacterial and fungal nitrification (*amoA*) and denitrification genes (*nirS*, bacterial and fungal *nirK*, *nosZ1* and *nosZ2*)

Results show field-scale variability in soil freezing rates throughout the sampling period, and an atypically low FT N2O emission event. Frozen soils harbored significantly higher gene abundance and activity compared to thawed soils for all genes, and *amoA*, *nirS*, bacterial *nirK*, and *nosZ2* transcripts. Differences were also found between crop rotations with nitrification gene abundance being higher in the conventional rotation, while denitrification gene abundance was often higher in the diverse rotation. Consequently, soil freezing dynamics have an impact on microbial nitrogen cycling communities driving GHG emissions and should be considered when predicting climate change impacts.

Tracking nitrous oxide production throughout a freeze-thaw cycle after fertilization with *vs* without a nitrification inhibitor

Trang Phan[1], Rich Farrell[2] and Kate Congreves[1*]

[1]Dept of Plant Sciences, [2]Dept of Soil Science, University of Saskatchewan,

*Correspondence: kate.congreves@usask.ca

In Canada, more than two-thirds of national nitrous oxide (N_2O) emissions are from agricultural soils. Improved fertilizer formulations—such as Enhanced Efficiency N fertilizers (EENF)—are a promising strategy for mitigating these N_2O emissions. To test the efficacy of a EENF product to reduce the risk for N_2O production if N fertilizer is applied in the fall (a common practice for large acreage cropping systems on the prairies), we conducted a 41-day soil incubation study. We compared urea-N fertilizer with and without enzyme inhibitors (*Nitrapyrin*) on i) the production mechanisms and ii) reduction potentials of N_2O *before and after soil freezing*. Soil microcosms (25 grams) were sealed in 1L jars and incubated under a sequential change in incubation phases: cold phase simulating fall (4°C for two weeks), freezing phase simulating winter (-10°C for one week), thawing phase simulating spring-thaw (4°C for five days), and warm phase simulating spring (23°C for two weeks). Different soil moisture treatments were tested (i.e., 55, 70, 80% soil water-filled pore space) for each fertilizer treatment and a non-fertilized control. Headspace gas samples were frequently collected during each temperature phase and analyzed for N_2O production and $^{15}N_2O$ isotopomers. Before soil thawing and also during the early stages of thawing, soil-derived N_2O emissions are fairly low across fertilizer sources and soil moisture—and nitrification and denitrification were equal contributors. After thawing, large amounts of N_2O were produced—predominately via denitrification, and especially when the water-filled pore space was 70%—but there was no difference with *vs* without the inhibitor. Overall, applying *Nitrapyrin* before the soil freezes may not translate into reduced N_2O emissions by the time that the soil actually thaws.

CH_4, CO and H_2 Inputs Trigger Community-level Physiological Responses in Soil

Authors: Anne de la Porte1*, Étienne Yergeau1, Philippe Constant1

Affiliations: 1Institut National de la Recherche Scientifique, Centre Armand-Frappier Santé Biotechnologie, Laval, H7V 1B7, Canada

*Corresponding author: anne.delaporte@inrs.ca

Trace gases oxidizing bacteria are ubiquitous in the soil environment and have a crucial role in controlling atmospheric chemistry. However, the ecophysiology of these organisms remain poorly understood. Here we hypothesize that trace gas sources in oxic soil environments enhance microbial activity and induce changes in community-level activity patterns, caused by the energy potential of gases supporting the mixotrophic metabolism of trace-gases oxidizing bacteria, and indirect effects on other members of the community through synthesis of extracellular enzymes and organic acids.
To test this hypothesis, we used a microcosm design in which a sandy-loam soil and a peat soil have been independently exposed to 0,05%, e.g. 500 ppmv, of methane (CH4) or carbon monoxide (CO) or molecular hydrogen (H2) for two weeks. This exposure represents a 500-1,000 times increase of atmospheric concentrations. For each set of microcosms, oxidation kinetics and calculations of the ATP yields induced, as well as community-level carbon utilization profiles and the quantification of functional genes by digital droplets PCR have been compared to control microcosms exposed to ambient air.

This experiment yielded contrasted results depending on the gas under consideration. Even though all the gases tested represent a significant energy source for specific subsets of the soil microbial community, and even if tested under the same concentration, the communities' response in terms of oxidation kinetics and ATP yields were dissimilar. Indeed, CH4 exposure have not been linked to an increased oxidation activity of this gas in the soils tested, when, for the same soils, H2 and CO exposures led to a strong increase in the oxidation activities of these gases. Moreover, ATP yields were higher for CO- than for H2- and CH4-oxidizing bacteria and the activation of the generalist functions investigated (e.g. carbon utilization) was decoupled to these ATP gains. This decoupling could either be explained by the different levels of diversity within each of the guilds stimulated (e.g. direct effects), or by the different interactions that these guilds have with other members of the soil community (e.g. indirect effects).

These results, along with the growing body of science surrounding microbial trace gases metabolisms, tend to confirm the initial hypothesis, by showing effects on specialized functions responsible for trace-gases oxidations, but also on more generalist functions involved in organic carbon metabolism. Future research should aim at ponderating the relative importance of direct versus indirect effects in shaping the community-level activity patterns observed in response of trace gases exposures.

Quantifying greenhouse gas emissions from beef cattle grazed pastures sod-seeded with non-bloat legumes.

Jiancan Liu, Joel Ens, J. Diane Knight, and Richard Farrell*
Department of Soil Science, 51 Campus Drive, University of Saskatchewan, Saskatoon, SK, Canada S7N 5A8
*Corresponding author. Email: r.farrell@usask.ca

A field study was carried out to compare GHG emissions from pastures sod-seeded with non-bloat legumes (sainfoin [*Onobrychis vicifolia*] and cicer milkvetch [*Astragalus cicer*]) with those from a typical bromegrass pasture with sparse remnant alfalfa. Research paddocks (*ca*. 65 m x 306 m) were established with a meadow bromegrass–alfalfa mix in 1998 and sod-seeded with non-bloat legumes in 2015. Measurement of soil-derived greenhouse gas (N_2O, CH_4, and CO_2) emissions from the paddock soils were initiated in the summer of 2017—starting a few weeks before the cattle were allowed onto the pasture and terminating at soil freeze-up in the fall. Since then, greenhouse gas (GHG) measurements have been conducted annually. The pastures were divided into three regions (front, center and back) and soil gas chambers were placed at three slope positions (upper, mid and lower) within each region. High-resolution LiDAR data was used to produce a digital elevation model (DEM) for each paddock that coupled with geospatial analysis to determine topographic indices (i.e., elevation, slope, and topographic wetness index) could then be related to GHG emissions and extrapolate point measurements to the paddock-scale. Results indicate that topography was the primary factor controlling GHG emissions from the grazed pastures with emission patterns exhibiting seasonal differences. Plant composition had little effect on GHG emissions. Our data also demonstrate the value of LiDAR-based DEMs as a tool for up-scaling GHG emissions from the point-scale to the pasture-scale.

Achieving greenhouse gas emissions reductions through precision manure management

Ryan Hangs, Jeff Schoenau, and Rich Farrell*
Department of Soil Science, 51 Campus Drive, University of Saskatchewan, Saskatoon, SK, Canada S7N 5A8
*Corresponding author. Email: r.farrell@usask.ca

Although field application of solid cattle manure (SCM) is an alternative, low-cost nitrogen (N) source to conventional synthetic fertilizers, gaseous losses of manure-N via volatilization and denitrification, are well documented. However, the effect of variable rate application of SCM on gaseous N emissions at a landscape-scale has received less attention. The objective of this study was to compare the nitrous oxide (N_2O), carbon dioxide (CO_2), and methane (CH_4) fluxes from watershed basins within the same field, with and without the addition of fresh feedlot SCM applied at either constant blanket or variable landscape-adjusted rates. The manure was applied in spring 2019 and gas samples were collected in 2019 and 2020 with gas sampling locations further classified according to landscape position and catchment area size. Although the cumulative CO_2 emissions were consistent between 2019 and 2020, the CH_4 consumption and N_2O emissions were greater in 2020. The warmer and drier conditions in 2020 supported increased autotrophic consumption of methane, while enhanced mineralization of slow-release organic manure-N increased soil NO_3^- available for denitrification in 2020. Despite these yearly differences, the trends in cumulative fluxes of each gas, among the treatments and among the landscape positions, were consistent between the two years, which is encouraging. Specifically, the non-manured watershed basins had relatively low cumulative N_2O and CO_2 emissions and were stronger CH_4 sinks, compared to manured basins. Additionally, basins receiving the variable rate manure application had lower N_2O emissions than those receiving the constant rate manure application. The low elevation, larger catchment area landscape positions contributed proportionally more to cumulative N_2O and CO_2 emissions, along with reduced CH_4 consumption, compared to the smaller catchment areas higher in the landscape, due to greater soil moisture and organic matter content within those depressional soils. Future work includes estimating the greenhouse gas intensities within each watershed basin and their relationship with barley N use efficiency of applied SCM and mineral fertilizer N.

Slow pyrolysis pine wood-derived biochar reduces nitrous oxide production from surface but not subsurface soil

Hongyuan Deng, Leanne Ejack, Shamim Gul, Shiv Prasher, and Joann Whalen*

Hydrochar and liquid-phase properties depend on feedstock type and temperature used for hydrothermal processing

Christopher Nzediegwu*, Yadi Tang, M. Anne Naeth, Scott X. Chang
Department of Renewable Resources, University of Alberta, Edmonton, Alberta

*Corresponding author: nzediegw@ualberta.ca

Hydrothermal processing of biomass under sub-critical conditions generates hydrochars (solid) that can be used to sequester carbon in soil and a liquid-phase that can serve as a source of nutrients. We evaluated how chemical properties of hydrochars and the liquid-phase were impacted by feedstock type and hydrothermal processing temperature using canola straw, manure pellets, sawdust and wheat straw, with hydrothermal conversion at 180, 240 and 300 ℃. Depending on the feedstock type, increasing hydrothermal processing temperature increased thermal stability and carbon recovery of the hydrochars and recoverable volume of the liquid-phase due to loss of solid matter and volatile compounds. Hydrochars produced at 300 ℃ rather than 240 and 180 ℃ would be more recalcitrant in soils due to their high thermal stability and fixed carbon content. Hydrochars from manure pellets would be most suitable as soil amendments due to their high ash content (64-77%) and non-saline electrical conductivity (0.24-0.58 dS m^{-1}). Increasing hydrothermal processing temperature increased liquid-phase pH towards neutral, affecting concentrations of calcium, magnesium and sodium in the liquid phase. Sodium adsorption ratio of the liquid-phase (0.2-4.5) was within acceptable levels set by the Government of Alberta for irrigation water. We conclude that feedstock type and temperature used for hydrothermal processing of biomass should be properly selected to optimize the design of hydrochars as low cost soil conditioners and liquid-phase as a source of nutrients.

Keywords: Biomass; carbon sequestration; hydrochars; hydrothermal processing; liquid-phase

Predicting the capacity for biochar to adsorb Pb from solution using feedstock physiochemical properties and pyrolysis temperature.

Presenting author: Chinonso Ogbuagu

Email: chinonsochukwuma.ogbuagu@pgr.reading.ac.uk

Chinonso |Ogbuagu[1]. Steve Robinson[1]. Alfonso Rodríguez-Vila[1]. Tom Sizmur[1]

[1]*Department of Geography and Environmental Science, University of Reading, UK.*

Abstract

The use of biochar for the adsorption of contaminants from soil and water has received considerable interest due to biochar's high surface area, negative charge, and resistance to degradation. However, a gap still exists on the selection of appropriate feedstocks and pyrolysis temperatures to obtain optimum sorption capability. In this study, biochars were produced from multiple feedstock materials (e.g. hay, wheat, straw, coco coir) at 10 pyrolysis temperatures ranging from 300ºC to 750ºC, at 50ºC intervals. The feedstocks and biochars were characterised for their pH, elemental composition, and functional groups. Batch sorption experiments were conducted to determine the maximum Pb sorption capacity for each biochar using the Langmuir model. The results obtained reveal that maximum sorption capacity increases with an increase in pyrolysis temperature, according to a sigmoidal relationship. The presence of oxygen functional groups, identified with FTIR spectra, and high pH explained the higher sorption of Pb in biochars created at higher pyrolysis temperature, due to electrostatic attraction and complexation mechanisms. Regression analysis between the feedstock physiochemical properties and the parameters of a sigmoidal model reveal insights that will enable us to select a feedstock and pyrolysis temperature, based on feedstock physiochemical properties.

Keywords: Biochar. Pyrolysis temperature. Surface area. Contaminant. Sorption capability. Feedstock. Functional groups. FTIR. Langmuir model. Sigmoidal model.

Feeding biochar to beef cattle – effects on manure nutrients and greenhouse gas emissions during composting.

Carlos M. Romero[1,2]*, Abby-Ann Redman[1], Jen Owens[2], Stephanie A. Terry[2], Gabriel O. Ribeiro[3], Thomas Oldenburg[4], Monika Gorzelak[2], Paul Hazendonk[1], Francis J. Larney[2], Xiying Hao[2], Tim A. McAllister[2], Erasmus Okine[1].

[1]University of Lethbridge, Lethbridge, AB, T1K 3M4, Canada.

[2]Agriculture and Agri-Food Canada, Lethbridge, AB, T1J 4B1, Canada.

[3]University of Saskatchewan, Saskatoon, SK, S7N 5A8, Canada.

[4]University of Calgary, Calgary, AB, T2N 1N4, Canada.

*Corresponding author: carlos.romero@uleth.ca

Abstract

Biochar in ruminant diets may alter enteric CH_4 emissions, but little is known about biochar-manure interactions during co-composting. We examined manure properties, organic matter (OM) composition, and greenhouse gas (GHG) emissions upon composting (CP) or stockpiling (SP) un-treated manure (M) or biochar-manure (BM) at full-scale. Manure piles were monitored hourly for temperature (30, 60, and 90 cm depths) and weekly for CO_2, N_2O, and CH_4 fluxes (top surface of manure piles) in a semiarid location near Lethbridge, AB, Canada. Solid M or BM samples were collected during the initial (0 d) and final (90 d) stages. Results suggest that biochar reduced microbial activity. Temperatures were frequently lower, on average ~6.1 °C, within BM than M materials (CP only). Such differences translated into higher cumulative CO_2 emissions from CP-M relative to CP-BM. By contrast, cumulative CH_4 and N_2O emissions were not affected by biochar treatment. Manure pH, total C (TC), NO_3-N, and Olsen P were not influenced by biochar either, although the C/N ratio was increased by 8.3% in BM relative to M. Moreover, it was observed that manure NH_4-N and water-extractable C (%) were 13.4 and 12.8% lower in BM than M ($P < 0.05$). Manure OM analysis in the solid-state (DPMAS ^{13}C NMR) demonstrated that BM was enriched by aromatic-C moieties, owing to indigestible biochar-C contributing to fecal OM. Producing compost from BM is consistent with current trends in circular economy, “closing the loop” in agroecosystems by returning C-rich organic wastes to soil. However, whole-farm studies are required to validate biochar as a tool to reduce the C footprint of beef production systems in western Canada.

Biochar-manure changes soil C mineralization in a Gray Luvisol used for agricultural production

T.L. Weber1, C.M. Romero2,3, M.D. MacKenzie1*

1Department of Renewable Resources, University of Alberta, Edmonton, AB, T6G 2E3, Canada.

2Department of Biological Sciences, University of Lethbridge, Lethbridge, AB, T1K 3M4, Canada

3Agriculture and Agri-Food Canada, Lethbridge, AB, T1J 4B1, Canada

Corresponding Author: *Derek MacKenzie, Tel: 1-780-492-6388; Email: mdm7@ualberta.ca

Pyrogenic carbon (PyC) is an important source of stable carbon (C) in soils; however, anthropogenic actions have removed this legacy substrate by suppressing wildfires in farming operations. Adding biochar (BC) to animal feed and utilizing the resulting BC-loaded manure as a soil amendment, may be a valuable strategy to restore PyC in densely populated livestock regions. A 64-d incubation study was conducted with a Gray Luvisolic soil (0-10 cm) collected from the Breton Plots (Breton, AB) to evaluate the effect of manure (160 Mg ha-1) on soil C and nitrogen (N) mineralization in the presence or absence of BC. Six treatments were included: (1) manure from cattle on a control diet (RM), (2) manure from cattle on a control diet with BC added at 2% of dry matter (BM), (3) pure biochar (BC) at 10 Mg ha-1, (4) a mixture of (2) and (3) (BM + BC), (5) a mixture of (1) and (3) (RM + BC) at the aforementioned rates, and (6) a non-amended control (CT) A total of 36 incubation bottles were prepared and incubated at 25°C and 65% of water-holding capacity. Manure increased CO_2-C emission rates, with the highest cumulative CO_2-C emissions being observed for RM + BC ($P < 0.05$). BM + BC halted soil C mineralization compared to RM + BC, as BC likely stabilized manure-C by increasing aromatic-C sources. By contrast, neither RM nor BM affected soil N mineralization (NO_3-N + NH_4-N) ($P > 0.05$). Applying BM might benefit soil C sequestration by lowering CO_2-C emissions over the long-term. Examining how microbial communities react to BM or RM + BC soil amendment is recommended for future research.

Shifts in nitrogen fractions in biosolids as affected by different treatment processes

Qianhan Le, G. W. Price, D. Burton, L.A. Phillips, and S. Yurgel
Email: qn565976@dal.ca

ABSTRACT

Sewage sludge needs to be properly treated before it is acceptable for land application as a biosolids. There are a number of treatment processes that result in different types of biosolids. These processes may cause fundamental changes to the biochemical properties of biosolids and consequently affect the quantity and rate of nutrient release (or mineralization), particularly nitrogen (N), which is the most limiting nutrient for crop production. The current biosolids standards are used for regulating pathogens and heavy metals, but the standard methods for agronomic evaluation of biosolids are few. Therefore, it is necessary to investigate the agronomic potential of different biosolids based on chemical characterization of N fractions.

In this study, four types of biosolids (heat-dried biosolids, N-Viro biosolids treated by enhanced alkaline stabilization, CaO-treated biosolids, and composted biosolids) were produced using the same source material, i.e. sewage sludge. Effects of the various treatment processes on the biosolids N forms and contents were evaluated. The majority of N in biosolids exists in organic forms and they must be converted to inorganic N forms (ammonium (NH_4^+), nitrite (NO_2^-), nitrate (NO_3^-)) via mineralization before it is available for plant uptake. The mineralization of N of four biosolid types amended to soil was examined by a short-term aerobic incubation study with periodic leaching. Biosolids (equivalent to 200 mg N kg-1 soil) were mixed with soil and sand, and the leaching procedure was repeated at 0, 3, 7, 14, 28 days. Leachates were collected for NH_4^+-N and NO_3^--N determination. It was hypothesized that treatment processes will significantly alter biosolids N fractions.

Predicting measures of soil health using the microbiome and supervised machine learning

Roland C. Wilhelm (rwilhelm@cornell.edu)
School of Integrative Plant Sciences, Bradfield Hall, Cornell University, Ithaca, NY, 14853, USA

Soil health encompasses a range of biological, chemical and physical properties that sustain the commercial and ecological value of agroecosystems. Benchmarking soil health requires a comprehensive set of diagnostics that can be cost-prohibitive for routine monitoring. The soil microbiome is a potential rich source of information about soil properties, which can be assayed in a high-throughput, cost-effective way. We evaluated the accuracy of random forest (RF) and support vector machine (SVM) regression and classification models to predict 12 measures of soil health, tillage status and soil texture from 16S rRNA gene amplicon data with an operationally relevant sample set. We evaluated the effects of standard processing methods for microbiome data and cross-validated the best performing models against independent datasets. Health categories and ratings could be predicted with the greatest accuracy for biological metrics, with the best models achieving a Kappa value of ~ 0.65 and a R^2 value of ~ 0.8, respectively. Models were weakly predictive of soil properties in independent datasets and, in one case, predictive of pastureland yields ($R^2 = 0.3 – 0.45$). Several taxa important for model accuracy exhibited clear relationships with soil nutrient conditions which underscored the ecological basis of predictions, namely *Pyrinomonadaceae*, *Nitrososphaeraceae* and Candidatus *Udeaobacter*. OTU-based models which had the most features were most accurate, signaling against rarefying, sparsity filtering or aggregating at higher taxonomic ranks. Our study provides the groundwork for developing scalable technology to reduce the cost of soil health diagnostics, which can promote the adoption and monitoring of soil health practices.

A soil health test for arable cropping systems in Saskatchewan Canada

Qianyi Wu[1] and Kate Congreves[1]

[1]Department of Plant Sciences, University of Saskatchewan

Farmers are looking for appropriate tools and methods for assessing and interpreting the health status of their soils; however, for Saskatchewan there is no standardized and prairie-based soil health test available. As such, we focused on developing a soil health testing protocol for arable cropping systems in Saskatchewan by building off of the Comprehensive Assessment of Soil Health (CASH) framework developed in the USA. In Sept and Oct 2018, soil samples (0-15, 15-30, and 30-60 cm depths) were collected from 55 arable fields across Saskatchewan—along with a couple native prairie samples. Various soil chemical, physical, and biological attributes were measured (23 attributes in total). Based on the data distribution for each attribute, we developed scoring functions. The results from multivariate analyses were used to determine the weighting factors needed to integrate the individual scores from each soil attribute into a single Saskatchewan Soil Health Score (SSHS). Soil C and N indices (soil organic C, active C, total N, and soil protein) produced the highest weighting factors. We also tested if there were linkages between the soil health scores and crop productivity by assessing the cereal yield trends for the past 10 yrs from the same rural municipalities where the soil samples were collected. A positive relationship between soil health and yields was most apparent during dry years; thus, we recommend further research to explore this linkage at a finer scale. Overall, this research forms the foundation of a promising tool for Saskatchewan producers who are interested in tracking soil health and using the results to inform management practices.

Atlantic Canada Biodiversity Project: an early look at the free-living nematodes of New Brunswick, Canada

Erika Helen Young*1,2, Claudia Goyer2, Louis-Pierre Comeau2, Sheldon Hann2, Kyle Mackinley2, Linda Elizabeth Jewell3, Adrian Unc4

1 Environmental Science Program, Memorial University of Newfoundland, St. John's, NL, Canada.

2 Fredericton Research and Development Center, Agriculture and Agri-Food Canada, Fredericton, NB, Canada

3 St. John's Research and Development Center, Agriculture and Agri-Food Canada, St. John's, NL, Canada

4 School of Science and the Environment, Memorial University of Newfoundland, St. John's, NL, Canada

*ehyoung@grenfell.mun.ca

The below-ground food-web reflects the surrounding soil environment and biotic groups may be used as indicators of changes in soil quality induced by land-use and land-use change. The objectives of the Atlantic Canada Biodiversity Project are to identify spatial patterns of soil properties with land-use in Atlantic Canada and to understand the relationship between the soil properties and biota including free-living nematodes. Free-living nematodes have been reported as good indicators of soil quality but have not yet been comprehensively evaluated in Atlantic Canada.

Several hundred samples were collected from 2019 to 2020 in the Atlantic provinces. In this assessment, we evaluated the nematode community in terms of trophic group abundances in soils of New Brunswick, Canada (NB). The relationships between ecoregion, land-use, soil classification, abiotic soil parameters and the nematode community were evaluated.

Nematode communities were distinct between ecoregion for the NB soil. The proportional abundance of bacterial feeders increased in managed systems (cropped and pasture) while natural systems (forest and wetland) were more closely associated with herbivore, fungivore, and carnivore abundance according to a multivariate analysis. The nematode community structure was influenced more greatly by land-use than ecoregion even for soils of the same classification. Nonetheless, the magnitude and type of shift in nematode communities under different land-use were dependent on soil classification. For example, Podzols had significantly more carnivores in forest than agricultural soil (mean of 75 and 3 individuals per 100 g of soil, respectively, $P=0.003$), this trend was less pronounced and not statistically significant for the Luvisols. Though nematodes are often correlated to soil organic carbon this was not the case for the NB soils suggesting that nematode abundance and structure may be reflective of the organic carbon fractions, an area of research that merits further investigation. This study suggested that the free-living nematode community composition was determined by the abiotic parameters driven by land-use and soil classification and demonstrated that nematode communities have the potential to be used as indicators of quality in soils of Atlantic Canada.

Mixed row and alternate row intercropping of chickpea-flax and pea-mustard combinations to enhance yield and nutrient availability

M. Reid, MSc Candidate, University of Saskatchewan, College of Agriculture and Bioresources, Department of Soil Science, melanie.reid@usask.ca

Dr. J. Schoenau, Professor, University of Saskatchewan, College of Agriculture and Bioresources, Department of Soil Science, jjs372@mail.usask.ca

Dr. J.D. Knight, Professor, University of Saskatchewan, College of Agriculture and Bioresources, Department of Soil Science, diane.knight@usask.ca

L. Shaw, Research Director, South East Research Farm, lshaw.serf@gmail.com

Intercropping can improve yield stability for non-competitive high-value crops. Legumes fix their own nitrogen, so intercropping with legumes is seen as a way to lower input costs. There is no published data on pulse-oilseed intercrops in western Canada soils. The effect of chickpea-flax and pea-mustard on yield and soil nutrient cycling in Saskatchewan soils was determined by comparing the crop yield, biological nitrogen fixation, and nutrient uptake of the pulse-oilseed intercrop combinations versus corresponding monoculture production. Seeding arrangements of monoculture legume, monoculture oilseed, alternate row intercrop, and mixed row intercrop with crop combinations of chickpea-flax and pea-mustard were sown into Brown Chernozem and Black Chernozem soils in Saskatchewan in 2019 and 2020. Soil N and P amounts and their supply rates, soluble soil C and N, and AMF (arbuscular mycorrhizal fungi) colonization were used to assess the effects of pulse-oilseed intercrops on soil nutrient dynamics. Chickpea had variable plant densities due to low germination from dry seeding conditions, a seeding rate error, and disease set-back which influenced flax grain yield across the 4 site-years. Intercrop flax grain yields were comparable to monocrop flax grain yields when chickpea plant densities were lower than the targeted rate. Grain yield and N and P uptake LER (land equivalent ratio) values for chickpea-flax show a clear benefit for intercropping in 2019 at the two sites, but not in 2020 which was a year with considerable heat and moisture-deficit stress. Grain and N and P uptake LERs for pea-mustard intercrops across the 4 site-years were greater than 1, indicating a net benefit to intercropping these crops together rather than as monocrops. Grain yield LERs for both crop combinations show no difference between mixed row and alternate row seeding arrangement for the intercrops.

Effect of biobased residues on the soil physio-chemical properties of two temperate agricultural soils

Badewa E. A.[1*], Yeung C.C.[2], Whalen J. K.[2] and Oelbermann, M.[1]

[1] School of Environment, Resources & Sustainability, University of Waterloo.

[2] Department of Natural Resource Sciences, McGill University.

*Corresponding Author email: ebadewa@uwaterloo.ca

Abstract:

The negative environmental impact of using mineral fertilizer for agricultural production has led to an increasing need for alternatives that can effectively provide plant nutrients to crops while enhancing soil health. The objective of this field study was to evaluate the effect of organic amendments (biobased residues) including composted food waste (compost), LysteGro biosolid slurry (biosolid) and liquid anaerobic digestate (digestate) on soil health characteristics. Soil was collected from 0-10 cm and 10-20 cm depth in 2018 and 2019 at an experimental site in Ontario and in Quebec. The effect of the three different biobased residues on soil health characteristics was quantified in comparison to mineral fertilizer. The soil health characteristics includes pH, aggregate stability, nitrate, ammonium, phosphorus, soil organic carbon, total nitrogen, soil microbial biomass, dissolve organic carbon and crop yield and biomass. So far, there was a significant difference ($p > 0.05$) in the soil health characteristics between the two locations and depths while little or no significant variation on soils amended with biobased residues and their crop biomass. The results identified the soil attribute important for regional soil health assessment and also demonstrated that mineral fertilizer can be substituted with biobased residues to ensure agricultural sustainability.

Keywords: soil health, crop biomass, composted food waste, anaerobic digestate, biosolids

Circular nutrient sources supply phosphorus and improve yields in organically managed systems

Jessica Nicksy*[1], Brian Amiro[1] and Martin Entz[2]
[1]*Department of Soil Science, University of Manitoba, Winnipeg, Manitoba, Canada.*
[2]*Department of Plant Science, University of Manitoba, Winnipeg, Manitoba, Canada*
**corresponding author email: nicksyj@myumanitoba.ca*

Phosphorus (P) nutrition is vital for crop growth and yield, but the global P cycle is broken. P enters the food system as fertilizer mined from rapidly depleting phosphate rock reserves, and leaves the food system via food and human wastes entering landfill or waterways. Excess P from urban wastes contributes to eutrophication of freshwater bodies. Meanwhile, P deficiency can limit yields, particularly on organic farms which often have negative P balances due to limited nutrient import options. Improved recycling of P from urban areas onto farmland is essential for food system sustainability.

Urban recycled (circular) P fertilizers are understudied compared to manure and conventional P fertilizers. This research evaluates three circular nutrient sources for their capacity to supply P and improve yields on a P-depleted soil of the Canadian Prairies. Frass is the excreta of black soldier fly (*Hermetia illucens*) larvae fed a diet of urban pre-consumer food waste. Digestate is the product of anaerobic digestion of urban food processing waste. Struvite is a phosphate mineral precipitated from municipal wastewater streams. Frass, digestate, and struvite are compared with monoammonium phosphate (MAP), a soluble conventional P fertilizer; compost, a common organic amendment; and an unfertilized control. In a wheat (*Triticum aestivum*) experiment replicated in two years, frass, MAP, compost, and digestate supplied more P and improved yields compared to the control. In an alfalfa (*Medicago sativa*) based forage experiment monitored over two growing seasons, all nutrient sources improved phosphorus uptake and yield compared to the control in the second growing season. In a pot experiment using Italian ryegrass (*Lolium multiflorum*), where adequate nitrogen (N) was supplied to remove any N effect of the amendments, all nutrient sources improved P uptake and yields compared to the control.

The role of riparian land-use systems in mitigating greenhouse gas emissions

M. Baskerville[1,] N. Chaganti[1], E. Ofosu[2], N.V. Thevathasan[2], M. Oelbermann[1*]

[1]School of Environment, Resources and Sustainability, University of Waterloo; [2]School of Environmental Sciences, University of Guelph

*Corresponding Author E-mail: moelbermann@uwaterloo.ca

Restoration of riparian areas adjacent to agricultural fields is a crucial measure to enhance water quality, but riparian zones located adjacent to intensively managed agricultural areas could also be a potential hot spot for greenhouse gas emissions (GHG). The objectives of this study were to quantify temporal variations in soil GHG emissions from a rehabilitated forested riparian zone (RH), a grassed riparian zone (GRS), two undisturbed natural forest riparian zones (UNFA/B) and an agricultural field (AGR). We also evaluated the effect of soil and environmental characteristics that influence GHG emissions. Soil CO_2 from the GRS riparian zone was significantly greater ($p<0.05$) compared to all other types of riparian zones and the agricultural field, whereas CH_4 emissions were significantly greater ($p<0.05$) in the UNFA site. Soil CO_2 emissions were significantly positively correlated ($p<0.05$) to soil temperature, where the greatest emissions for all riparian zones and the AGR site occurred in the summer. Soil moisture was significantly positively correlated to CH_4 emissions and negatively correlated to CO_2 emissions ($p<0.05$). Overall global warming potential mg (CO_2-C m^{-2} h^{-1}) for the agricultural field (534), rehabilitated riparian zone (635.80) and undisturbed natural forests (686) were significantly lower ($p<0.05$) compared to the grassed riparian zone (1345). Mean soil N_2O emissions were not significantly ($p<0.05$) different among all riparian zone types and the agricultural field. Nitrous oxide emissions were greatest in the AGR site compared to the various riparian zones and were significantly higher in maize (64 μg N_2O-N m^{-2} h^{-1}) than in soybean (20 μg N_2O-N m^{-2} h^{-1}) cropping season. Emissions of N_2O were significantly ($p<0.05$) correlated to soil and air temperatures at the GRS and RH sites and significantly ($p<0.05$) correlated to soil nitrate in the AGR site. We concluded that forested riparian zones have lower emissions than grassed riparian zones and agricultural fields. Further, soil microclimate rather than chemical characteristics influenced temporal GHG emissions.

Cultivating Salix in Agricultural-Riparian Transition Areas to Mitigate Agriculturally Derived N_2O Emissions from Potato Cropping Systems on Prince Edward Island

Authors: Holly Wilts (B.Sc., M.Mus., Ph.D. Candidate in Environmental Science (UPEI); hdwilts@upei.ca), David Burton (Ph.D., P.Ag.), Aitazaz Farooque (Ph.D., P.Eng.).

Cultivating shrub willow (Salix) in agricultural-riparian transition areas has been proposed as a beneficial management practice for mitigating elevated riparian nitrous oxide (N_2O) emissions in agricultural regions. N-based fertilizers are water-soluble, enter riparian areas through surface runoff and subsurface lateral flow, and are converted to N_20 by incomplete anaerobic denitrification. By intercepting fertilizer derived nitrate (NO_3^-) as it is transported off agricultural fields, it is thought that Salix buffer strips will recycle NO_3^- into the willow biomass, reducing the amount at risk of denitrification and subsequent loss from the system.

Our study investigated the impact of 2–4-year-old agricultural-riparian *Salix Viminalis* buffers relative to a grass buffer and upslope cultivated fields in potato rotation at 5 research sites across Prince Edward Island (PEI), Canada. Greenhouse gas (N_2O, CO_2, CH_4) flux at the soil-atmosphere interface was measured using non-steady-state static chambers during the growing season (May to November) in 2018 and 2019. NO_3^- exposure was determined using Anion Plant Root Simulator (PRS) probes (Western Ag Innovations), and soil temperature/moisture content and air temperature/humidity were measured. The willows were managed for maximum nutrient uptake by coppicing on a 3-year cycle and regular (biweekly) mowing of understory grass.

Our study found that agricultural-riparian Salix can significantly mitigate fertilizer induced N_20 emissions even when high NO_3^- inputs occur from upslope agricultural fields and following precipitation events when the potential for nutrient saturation is more likely. Mean cumulative seasonal reductions of 1.32 kg N ha^{-1} (-0.021 to 6.16 kg N ha^{-1}) were observed in Salix relative to cultivated fields. The mean cumulative average global warming potential of Salix was 409 Mg CO_2e ha^{-1} lower than cultivated fields, with reductions of up to 1813 Mg CO_2e ha^{-1}, and differences in N_2O flux between treatments was the biggest influencing factor. No hot-moments of N_20 emission were observed in Salix following high rainfall events, which coincided with up to 95% decreases in N_2O emissions in Salix relative to cultivated fields. These results demonstrate that cultivating Salix on downslope field edges bordering riparian areas is an effective strategy for mitigating agriculturally derived riparian N_2O emissions on PEI.

Comparing Greenhouse Gas Emissions from Agricultural Crops and In-Field Seasonal Wetlands

Waqar Ashiq[1], Hiteshkumar Vasava[1], Uttam Ghimire[2], Kari Dunfield[1], Prasad Daggupati[2], Asim Biswas[1*]

[1]School of Environmental Sciences, University of Guelph, Guelph, ON, N1G2W1, Canada

[2]School of Engineering, University of Guelph, Guelph, ON, N1G2W1, Canada

Abstract

Agricultural intensification increases nutrient pollution to low-lying areas of the landscape and is predicted to increase atmospheric greenhouse gas (GHG) emissions. Due to different soil water content and nutrient runoff, the seasonal agricultural wetlands and surrounding buffer zones might act as hotspots of GHGs. However, the pattern and net GHG emissions budget from these landscape units ie required to mitigate landscape level GHG emissions. We conducted a two-year field experiment to examine the relative contribution of different agricultural landscape units towards GHG (N_2O, CH_4, and CO_2) emissions and their relative contribution towards global warming potential (GWP). The specific objectives included, i) to characterize the GHG emission potential of seasonal wetland (T1), buffer zone (T2), and cropland immediate to buffer zone (T3), ii) to compare GHG emissions from these three landscape units to adjacent cropland (T4), and iii) to quantify the contribution of these ecological units towards GWP. During 2019, N_2O ranged from 0.9 - 78 g ha^{-1} d^{-1}, CH_4 from -10 - 2723 g ha^{-1} d^{-1}, and CO_2 from 7 - 36 kg ha^{-1} d^{-1}. Average N_2O emissions were significantly ($P<0.05$) higher from T3, followed by T2, T1, and T4, respectively. Similarly, significantly ($P<0.05$) higher CH_4 emissions were observed from T1, followed by T2, T3, and T4, respectively. The CO_2 emissions pattern was as T2>T1>T3>T4, respectively. In 2020, N_2O emissions ranged between -0.2 - 108 g ha^{-1} d^{-1}, CH_4 emissions from -171 - 89 g ha^{-1} d^{-1}, and CO_2 ranged from 12 - 701 kg ha^{-1} d^{-1}. Average N_2O emissions were significantly ($P<0.05$) higher from T4, followed by T3, T2, and T1, respectively. The CH_4 emissions followed a pattern as T1>T3>T2>T4 and CO_2 emissions were observed as T4>T2>T3>T1, respectively. During 2019, T1, T2, and T3 had higher GWP (3318, 2206, and 2473 kg CO_2 equivalent ha^{-1}, respectively) than T4 (1701 kg CO_2 equivalent ha^{-1}). In 2020, the magnitude of GWP from T1, T2, and T3 was 1.8, 4.4, and 1.3 times higher than respective treatments in 2019. Due to emission peaks in T4 following farm operation, the GWP from T4 was significantly higher (18547 kg CO_2 equivalent ha^{-1}) than other treatments. However, these results are based on one seasonal wetland, limiting the generalization of these findings over all seasonal wetlands in different agricultural landscapes. Further monitoring over multiple years and landscapes could help analyze the GHG emission behavior of seasonal agricultural wetlands and provide further insights into management decisions.

Keywords: Buffer zone, cropland, global warming potential, farm water bodies

Purpose: Poster presentation (student competition)

Presenter: Waqar Ashiq (washiq@uoguelph.ca), Ph.D. Candidate

***** Correspondence: biswas@uoguelph.ca; Tel.: +1-519-824-4120 (ext. 54249); Fax: +1-519-837-0756

Effect of drainage system on soil greenhouse gas emissions from highbush blueberry fields in British Columbia

Paula Resque Porto[1,*], Andy Black[1], Maja Krzic[2], Zoran Nesic[1], Paul Jassal[1] and Sean Smukler[1]
[1]Applied Biology, Faculty of Land and Food Systems, University of British Columbia, Vancouver, BC V6T 1Z4, Canada; [2]Faculty of Land and Food Systems/Faculty of Forestry, University of British Columbia, Vancouver, BC V6T 1Z4, Canada

Managing soil drainage is crucial for agricultural production in regions with humid climate and poorly drained soils. Soil water content is an important driver of soil greenhouse gas (GHG) emissions; however, the impact of artificial drainage practices on emissions has not been extensively studied in perennial agroecosystems. An observational study was conducted in nine fields planted with highbush blueberries (*Vaccinium corymbosum* L.) on silt loam Gleysols in Delta, British Columbia. The following three drainage systems were investigated: (i) *undrained*, (ii) *drained* with subsurface tiles, and (iii) drained with tiles and pumps (*pumped*). Carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) fluxes were measured every two weeks from July 2017 to April 2019 using the non-steady-state chamber technique. Drainage system had no effect on net cumulative GHG fluxes after 22 months, or during each year of sampling. However, in the spring of year 1, undrained fields emitted significantly more CO_2 than drained fields ($p = 0.01$). Large variability was observed in the spatiotemporal patterns of GHG fluxes, both among and within drainage groups. N_2O emissions predominated in the spring of year 1 (37% of annual emissions) and in the fall of year 2 (41%). In year 1, soils were a net sink of CH_4 in every season except the summer, but in year 2 they were a sink only in the summer. Peak N_2O and CH_4 fluxes occurred during winter months in the undrained fields and during spring in the drained fields. In the fields with pumped drainage, peak N_2O fluxes were measured in the fall, and peak CH_4 fluxes in the summer. Minimal differences observed among the drainage systems suggest that other management or edaphic factors are likely driving emissions. Analysis of these covariates will help to identify practices that will enable farmers to reduce GHG emissions. Furthermore, quantifying GHG emissions from soils in blueberry production will improve our provincial agricultural GHG emission estimates and our understanding of the processes involved.

*Corresponding author. Email address: paula.porto@ubc.ca

Enhancing soil organic carbon storage through forested buffers and biochar application in agricultural lands

Cole D. Gross1*, Edward W. Bork2, Cameron N. Carlyle2, Scott X. Chang1*
1 Department of Renewable Resources, Faculty of Agricultural, Life and Environmental Sciences, University of Alberta, 442 Earth Sciences Building, Edmonton, AB T6G 2E3, Canada
2 Department of Agricultural, Food and Nutritional Science, Faculty of Agricultural, Life and Environmental Sciences, University of Alberta, 410 Agriculture/Forestry Centre, Edmonton, AB T6G 2P5, Canada
* Correspondence: cgross@ualberta.ca (C.D.G.); sxchang@ualberta.ca (S.X.C.)

Tailoring agricultural management practices to increase soil organic carbon (SOC) storage and reduce greenhouse gas (GHG) emissions can help mitigate climate change and improve ecological goods and services generated by agriculture. We conducted a 3-yr field study in central Alberta, Canada in two common types of agroforestry systems: hedgerows (legacy woody perennial vegetation) and shelterbelts (planted woody perennial vegetation). In the cropland, we compared manure compost (MT) and biochar (BT, charred MT) applications with a control (CT, no treatment). We also compared SOC and GHG emissions between CT and adjacent perennial vegetated areas, either with (+WT) or without (-WT) a woody component or planted saplings (PT). Two years post treatment application, BT contained 12 Mg ha^{-1} more SOC in the surface soil relative to CT, +70% compared to the applied C rate. In 2018 and 2019, MT increased annual GHG emissions by 33%, on average, relative to CT and BT. In 2020, BT reduced annual GHG emissions by 21%, on average, relative to CT and MT. In the surface soil, +WT contained 74% (21 Mg ha^{-1}) more SOC relative to CT. Cumulatively, +WT contained 64% (111 Mg ha^{-1}) more SOC relative to CT, wherein the subsoil (~30–100 cm) comprised 66% of the total SOC difference between the land uses. Perennial vegetation contained more SOC in particulate form, while CT contained substantially less mineral SOC physically protected in aggregates. Our study shows that the application of biochar, rather than its manure compost precursor, increased surface SOC sequestration and had no effect or reduced GHG emissions relative to no treatment. Additionally, we show that established woody perennial vegetation increases SOC storage and protection in agricultural lands in both surface and deep soil. Policy and C sequestration initiatives should incentivize biochar application and agroforestry systems as viable climate change mitigation agricultural practices.

Assessment of a Two Timestamp vs. a Four Timestamp Chamber Sampling Method for Calculating Soil Greenhouse Gas Fluxes

Autumn Wiebe[1, 2]*, Alexander Koiter[1] and Aaron Glenn[2]

[1]*Department of Geography & Environment, Brandon University, Brandon, Manitoba, Canada.*

[2]*Agriculture and Agri-Food Canada, Brandon Research and Development Centre, 2701 Grand Valley Rd, Brandon, Manitoba, Canada.*

autumnwiebe@gmail.com

Quantifying soil greenhouse gas (GHG) fluxes is important because of climate, soil health, nitrogen use efficiency and influences of cropping inputs (e.g., fertilizer). To measure GHG fluxes from agricultural soils, the chamber method is often used, where three or more concentration points are commonly taken from each chamber over time. For this study, a comparison of a common four timestamp method (4TS) with a less frequently used two timestamp method (2TS) was conducted in order to assess the use of the 2TS method. Some benefits of using a 2TS method are less chamber headspace measurements needed to estimate fluxes allowing for a greater number of chambers to be deployed resulting in improved spatial and/or temporal coverage of the GHG fluxes in a field with little impact on the cost of analysis or time spent sampling. Paired chambers of both methods were monitored in four experimental treatments from a study investigating soil and vegetation management for a dual-purpose perennial grain crop. This approach allowed for a direct comparison of the two chamber measurement methods and the assessment of the impact of the different experimental treatments on soil GHG emissions, along with providing a better way to capture and quantify the spatial variability of GHGs. Preliminary results show that the 2TS method may be underestimating the flux of nitrous oxide (N_2O), carbon dioxide (CO_2) and methane (CH_4) more than the 4TS method. An implication of this study is to analyze the benefits and drawbacks of each of the sampling methods with hopes of contributing to a standard operating procedure on when it is appropriate to use each of these different methods. This could allow both researchers and farmers to save money as the researchers could reduce their cost of analysis per chamber while providing information to farmers for better nitrogen fertilizer management.

Time to Ponding and Soil Sorptivity: An Historical Perspective with Climate-Change Implications.

Gary Parkin, School of Environmental Sciences, University of Guelph. gparkin@uoguelph.ca

During an intense rainfall event, water may eventually pond on the soil surface potentially leading to runoff. Knowing the elapsed time between initiation of rainfall and ponding (time to ponding, t_p) is of critical importance in accurately modeling soil-water hydrology today and in the future. The objectives of this talk are to: 1) cover historical aspects of t_p including available analytical solutions and other approximations that include soil physical parameters such as sorptivity, hydraulic conductivity, porosity, and tension at the wetting front and 2) use HYDRUS 1-D to assess the impact of soil layering and non-uniform initial soil water content on t_p. Analytical solutions of Richards' equation for estimating t_p can be divided into three types: linear, weakly non-linear, and non-linear. Other quasi-analytical approaches for estimating t_p include the methods of Green and Ampt and Parlange and Smith. Time to ponding derived from non-linear analytical solutions are generally considered to be the most accurate of these approaches. Field studies have shown that these solutions give reasonable results if the rate of rainfall is greater than 1.5 times the soil's saturated hydraulic conductivity. All of the approaches rely on certain restrictive assumptions such as 1-D vertical water flow, constant rate of rainfall greater than the soil's saturated hydraulic conductivity, homogeneous soil and uniform initial soil water content. HYDRUS 1-D was applied to investigate the impact of the last two assumptions on soil sorptivity and t_p. By varying the A-horizon thickness of a typical loam soil and applying a constant rainfall rate about 1.5 times its saturated hydraulic conductivity it is shown that the A horizon must be at least 40-cm thick to justify the homogeneous soil assumption. Since A-horizon thickness had little impact on soil sorptivity, the remaining soil hydraulic properties were responsible for the variation in t_p generated by HYDRUS 1-D. Next, using the same A-horizon's soil physical properties, the impact of a non-uniform distribution of initial soil water content down to 40-cm depth was investigated using HYDRUS 1-D. There was a small impact on soil sorptivity of less than a factor of 1.5, whereas t_p varied over a factor of about 2.5 with largest value under dry soil conditions. In the future climate change may influence t_p through more intense rainfall events, enhanced soil drying between rainfall events, less intensive soil freezing in winter, changes in soil organic matter content, new cropping systems, and so on.

Enhancing soil drainage estimation by coupled soil and groundwater flow modeling

Yefang Jiang
Agriculture & Agri-Food Canada, Charlottetown, PEI, Canada

Soil drainage data are required for assessing agrochemical leaching flux and associated loading to receiving groundwater, but accurately measuring soil drainage is challenging. Therefore, soil drainage data are commonly estimated from soil water flow modeling. Sorensen et al. (2014) showed that four different soil moisture models produced largely different drainage values although they all honored the same moisture dataset within acceptable errors. Their study demonstrated that soil water flow modeling could lead to non-unique estimation of soil drainage. A coupled LEACHM and MODFLOW approach is proposed to reduce the risk of non-uniqueness of soil drainage modeling. Briefly, a LEACHM model (Hutson, 2003), which is a deterministic 1D model that simulates plant water/nutrient uptake, and flow and solute transport in the subsurface, was developed to simulate soil drainage. At the same time, a watershed-scale 3D groundwater flow model was also developed using MODFLOW. The LEACHM and MODFLOW models were tcoupled loosely by utilizing the daily drainage predicted by LEACHM as recharge for the MODFLOW. It was assumed that seasonal groundwater recharge is derived from the moisture stored in the vadose zone and is being pushed downward to the water table by the newly-added soil drainage on the top of the vadose zone column through nearly instant pressure propagation (Jiang et al. 2017; Kalisman et al. 2019). The LEACHM model is calibrated and verified against soil moisture measurements while the groundwater flow model is calibrated and verified against both water level and base flow data. This coupled modeling system allows soil moisture, groundwater level, and stream flow (e.g., base flow) measurements to be used to constraint soil drainage estimation. Simultaneously using multiple variable measurements of the system to constraint the models can reduce the risk of modeling non-uniqueness, compared to using soil moisture measurements alone. This approach was tested in the Winter River watershed and surrounding areas in Prince Edward Island (PEI). The LEACHM model was developed by following the approach proposed by Jiang et al. (2011) with a simulation period of 1 June 2014 to 31 May 2017 at a uniform time step of 0.1d. The MODFLOW model developed by Jiang et al. (2011) was adopted as the groundwater flow model. Using the simulated soil drainage based on soil texture measurements made in a field within the groundwater flow domain as groundwater recharge did not produce the best matches of groundwater level and base flow. However, the fits of soil moisture, water level and base flow were all improved to acceptable ranges as the silt content was adjusted from 38 to 25% by accordingly increasing sand content. Varying soil column length from 0.5 to 9 m showed that the 0.9-m soil column produced the best model fits. Under deep snow cover conditions, the model fits were not acceptable where manual adjustments on drainage prediction were required to improve model fits. This work shows that the coupled modeling approach can reduce the risk of non-uniqueness of soil drainage modeling, provided that the geology is relatively homogeneous, and water table is relatively shallow and responds sensitively to drainage events.

CHARACTERIZING CARBON COMPLEXITY ACROSS THE LAND-WATER INTERFACE IN AGRICULTURAL LANDSCAPES

Authors: L.A. Weller, University of Windsor / Great Lakes Institute for Environmental; Research; C.M. Febria, University of Windsor / Great Lakes Inst. for Environmental Research; J.D. Hosen, Perdue University; C. Proctor, University of Windsor.

Rationale:

Carbon may be a key underexplored factor in nutrient management across human-impacted landscapes and downstream receiving waterbodies. Landscape-level characteristics, such as land-use, greatly influence the quantity and quality of dissolved organic matter (DOM) exported into freshwater ecosystems. Light-emitting fluorescent fractions of DOM (FDOM) have been linked to broad land-use categories. However, using FDOM to characterize carbon in agricultural landscapes with respect to practices that build soil health remains largely unexplored.

Objectives:

My research aims to characterize the dynamic relationship between soil and water DOM in human-impacted landscapes. Specifically, it asks the question: to what extent can FDOM be used to characterize carbon in agricultural landscapes? Using the low-topography, clay-dominated soils of Essex County in southwestern Ontario as a case study we conducted a field survey to characterize DOM across the land-water interface using FDOM as a tracer across a suite of farm-based agricultural practices related to carbon.

Methods:

Field surveys were carried out during the Summer and Fall months of 2020 on farms located within Essex County. Individual fields were selected to along a gradient of management practices (n=13) including conventional agriculture with full tillage (CV), no-till (NT), conservation tillage with cover crops (CC), conservation tillage with microbial amendments and cover crop rotations (CCM), and restored Carolinian forest (FS), where soil type is constant (Brookston Clay) and agricultural fields are drained by a tile network which is limited to a single field of the same management practice. A total of 10 boreholes per field, 1 per acre, were sampled (using a pre-determined 10-acre grid design) to a depth of 60 cm and separated into four depth increments (0 – 15 cm, 15 -30 cm, 30-45 cm, 45-60 cm). In-situ measurements of soil moisture, temperature, and bulk electrical conductivity were recorded at each borehole. Soil organic carbon (TC) and total nitrogen (TN) concentrations were determined using a Shimadzu TOC-vCPH total organic carbon analyzer with attached TNM-1 total nitrogen analyzer. DOM was analysed using samples prepared and leached in ultrapure Milli-Q® water as per Romero (2017). DOM was measured primarily as dissolved organic carbon (DOC). Fluorescence excitation−emission matrices (EEMs) will be acquired using a Horiba Aqualog. DOM quality metrics from fluorescence EEMs, were obtained using a Parallel Factor Analysis (PARAFAC) analysis conducted using R and compared to other objective measures of soil and water health to establish if there is a significant correlation between the observed FDOM signals (EEMS) in each field site treatment and the corresponding water and soil health indicators.

Conclusion:

Here we discuss our farmer-centered approach to the field study and share preliminary results. Establishing relationships between DOM and management practices in the lower Great Lakes basin of Canada is especially critical where fundamental explorations at the agricultural soil-freshwater interface are focused on P-management. By examining DOM in the context of other macronutrient cycles our work may provide critical insight into mechanisms modulating P-release or retention from soils, and therefore inform regional policy and management.

Deep Soil Water Uptake of *Pinus Banksiana* in the Boreal Plain Ecozone of Saskatchewan

Authors: Eric John Neil*, Bing Cheng Si.

Department of Soil Science, University of Saskatchewan, Saskatoon, SK, Canada.

*Corresponding author: eric.neil@usask.ca

While much is known about the interactions of soils and vegetation in the top 1 m of the soil profile, deep soil or soil below 1 m, is typically ignored with respect to its contribution to transpiration. However, there has been increased evidence that root systems can penetrate far deeper, where they may have access to additional water. Although deep roots represent a relatively small proportion of the total root biomass in forest ecosystems, they may take up water from deep soils and actively contribute to transpiration. As such, deep roots have the potential to provide a crucial drought-mitigation mechanism in water-limited environments. Therefore, it is hypothesized that deep-rooted boreal forest vegetation uptake water from deep soil, resulting in a significant contribution to transpiration. The objective of this study is to estimate the depth-wise root-water uptake of *Pinus Banksiana* trees in order to improve our understanding of the interactions between deep-rooted vegetation and deep soil water resources of boreal forest ecosystems. To address this, a stand of *Pinus Banksiana* in Nisbet Provincial Forest, SK, was monitored throughout the 2019 growing season. To develop a hydrologic balance and to aid in tracking and quantifying the movement of water through the soil-plant-atmosphere system, several site-specific variables were monitored. Heat pulse probes within the trunks of growing trees measured sap flow velocities, time domain reflectometry probes monitored volumetric soil water content and matric potential, and water potentiometers identified leaf water potentials. The rooting distributions of the study trees were determined through the separation of roots from bulk soil samples. Furthermore, stable isotopes of water were used as environmental tracers to identify the depth-wise sources of soil water taken up for use in primary production. With the aid of hydrologic modelling, the information obtained through sampling and monitoring have been used to estimate the sources and magnitudes of plant water uptake throughout the growing season. Our results indicate that while the majority (>90 %) of the root mass of *Pinus Banksiana* are located in near-surface soils (< 1 m), a portion of its root mass is located within deep soils and is responsible for a considerable amount of the total root-water uptake. Furthermore, the proportion of deep root-water uptake may be modified by changing soil, plant, and climatic conditions.

Do overwinter plastic tarps provide better nutrient and water retention than cover crops?

Raelani Kesler[1], DeLisa Lewis [1], Kira Borden [1], Maja Krzic[1,2], Sue Grayston[2], Sean Smukler[1]

[1]Faculty of Land and Food Systems, University of British Columbia, Vancouver, BC, Unceded xʷməθkʷəy̓əm (Musqueam) Territory; [2]Faculty of Forestry, University of British Columbia, Vancouver, BC, Unceded xʷməθkʷəy̓əm (Musqueam) Territory

Predicted increases of spring and fall rainfall due to climate change will lead to numerous challenges in agricultural production, including challenges with establishing winter cover crops in some regions of British Columbia (B.C.). Without cover during the fall and winter months, soils under the influence of heavy precipitation are liable to erode and leach nutrients. In response, some vegetable farmers are utilizing plastic tarps to protect soils over the fall and winter, but little is known about the effects of these tarps on soil biophysiochemical properties and crop yield. The objective of this study is to evaluate the effects of overwinter plastic tarping on soil properties (PAN, EC, VWC) and crop yield on two farms with soils of contrasting textures, loamy sand and silt loam. This study is conducted on two organic certified vegetable farms – the University of British Columbia (UBC) Farm (Vancouver, B.C.) and Green Fire Farm (Duncan, B.C.). Each farm site hosts 16 paired comparisons of annually cover cropped and tarped plots arranged as a randomized complete block design. Tarp installation and cover crop planting occurred in the fall of 2019. Plant available nitrogen (PAN) and electrical conductivity (EC) were measured at 0-15 cm depth in all plots at the time of tarp removal in the spring of 2020. Average nitrate concentrations were significantly greater in tarped plots compared to cover cropped, 16 ppm and 2 ppm, respectively, and EC values followed a similar trend. Soil volumetric water content (VWC) was measured at 0-6 cm depth in all plots at the time of tarp removal, and at UBC Farm only, it was measured every 2-3 weeks from tarp installation until time of planting in 2019-2020. Trends at UBC Farm showed that tarped plots had lower VWC overwinter, but higher VWC beginning in early spring until tarp removal. Marketable yield of beet and fennel crops were measured in the fall of 2020 using a subsample of crop biomass from each plot, no difference between treatments was observed. Preliminary results from the first year of this study indicate that overwintering fields with plastic tarps retain more PAN and spring moisture in soils than cover, which will help farmers make informed soil management decisions.

Funding for this project has been provided by Climate and Agriculture Initiative BC through the Farm Adaptation Innovator Program

Cover crops can, but do not necessarily, improve soil health in horticultural rotations

Carolyn B. Marshall*, David L. Burton, and Derek H. Lynch
Department of Plant, Food, and Environmental Sciences, Dalhousie University, Truro, Nova Scotia, Canada B2N 5E3
*Presenting Author: cmarshall@dal.ca

Production of fruits and vegetables provides nutrient dense and high values crops. However, horticulture production is often very intensive, with high levels of soil disturbance, high use of agricultural inputs, and with prolonged periods of exposed soil. This can lead to increased soil degradation when compared to other types of cropping. To assess the impact of cover crop use in horticulture production, we used a subset of the Atlantic Soil Health Lab's database of on-farm soil samples collected between 2016-2018. We used data from 14 fields, seven of which incorporated cover crops in their rotation and seven of which used no cover crops. We analyzed 21 soil health parameters and found inclusion of cover crops significantly increased permanganate oxidizable carbon (active carbon), soil respiration, ACE protein, residual soil nitrogen, and biologically available nitrogen. However, we also found that the variation in these parameters was greater when cover crops were part of the rotation. We feel this is due to the wide range of cover crop species and the management used, such as the method of cover crop termination. While cover cropping is seen as a best management practice to improve soil health, simply incorporating a cover crop into a horticulture rotation does not necessarily lead to improved soil health. Research trials on specific cover crop use to target soil degradation are needed to tailor recommendations to ensure the desired outcomes can be achieved with cover crop use.

Using Pea-Based Cover Crop Mixtures for Nitrogen Supply in Quebec Organic Grain Crop Production.

STÉPHANIE LAVERGNE[1], ANNE VANSSE[2], MARIE-NOËLLE THIVIERGE[3], CAROLINE HALDE[2]
[1]Department of Plant, Food, and Environmental Sciences, Dalhousie University, Truro, NS; [2]Département de phytologie, Université Laval, Quebec City, QC; [3]Agriculture and Agri-Food Canada, Quebec Research and Development Centre, QC.
Email: stephanie.lavergne@dal.ca

Providing enough nitrogen (N) to organic corn is challenging for organic growers, as they rely heavily on cover crops (CC) including multi-species mixtures. However, few studies have attempted to quantify corn N use efficiency from these CC mixtures. The impact of fall-seeded cover crops with or without pelletized poultry manure application on corn yield and N dynamics was investigated in a field experiment conducted at three sites in Quebec, Canada. The study included a fall cover crop phase (year 1) and a grain corn phase (year 2). Cover crop treatments consisted of field pea (*Pisum sativum* L.) as a cover crop in a pure stand, or in 2-, 6- and 12-species pea-based mixtures, and of a weedy control without cover crops. Prior to winter killing frost, field pea was the predominant species within all mixtures. Moreover, as the number of CC species increased within the mixtures, aboveground biomass of field pea decreased. Total aboveground biomass and N content of CC tended to be the greatest in pure stand of field pea and the lowest in the weedy control. Nitrogen content of CC roots averaged 13 kg N ha^{-1} and accounted for 14% of CC total N content for all CC treatments. Corn grain yield was on average 28% greater following cover crops than the weedy control. Corn yield increased following pure stand of field pea, 2- and 12- but not 6- species mixtures, showing no clear advantage of using mixtures instead of a pure stand of field pea regarding N supply and corn yield. Corn yield increased by 10% with poultry manure application irrespective of cover crop treatments. This research confirms the benefits of using CC in organic corn production systems. However, other species and seeding rates within pea-based mixtures would be worth testing to ascertain if CC mixtures can lead to additional benefits.

INTERCROPPING LEGUMES IN ANNUAL CROPS AFFECT ABOVE- AND BELOWGROUND BIOMASS PRODUCTION AND SURFACE SOIL PROPERTIES.

Insaf Chida1, Vincent Poirier1 and Daphné Touzin2
1 Université du Québec en Abitibi-Témiscamingue (UQAT), Unité de recherche et développement en agriculture et agroalimentaire (URDAAT), 79 rue Côté, Notre-Dame-du-Nord, QC, J0Z 3B0.
2 Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, Direction régionale de l'Abitibi-Témiscamingue et du Nord-du-Québec, 180 boul. Rideau bureau 2.01, Rouyn-Noranda, QC, J9X 1N9.

Intercropping legumes can promote the development of soil structure, increase the formation of water-stable macroaggregates and improve soil porosity, in addition to enriching the soil with organic matter, carbon (C) and nitrogen (N) through the input of above- and belowground plan biomass and controlling weeds. However, the soil and climatic conditions in Abitibi and Témiscamingue can make the implementation and success of this practice difficult. The lack of information on techniques and types of legumes to be used limits the adoption of this practice by farmers. This project aimed to implement two field trials with two organic field crop producers located in Poularies, Abitibi, and Laverlochère, Témiscamingue. Our results show that the establishment of red (*Trifolium pratense*) and white (*Trifolium repens*) clover at seeding significantly reduced the quantity of weeds found in the inter-row and provided significant quantities of C and N from above- and belowground biomass. Crimson clover (*Trifolium incarnatum*) produces more biomass, but its chemical composition could make it more difficult to decompose compared to white clover. The latter could enrich the soil surface in C and N in the short term, while crimson clover could promote the stability of the soil structure. The use of these two species in combination is an interesting avenue to explore in future trials. It would be relevant to better characterize the root biomass of each of these species and to follow the dynamics of C and N at the surface and at depth the year following their burial in the soil.

How do introduced non-bloat legumes impact carbon and nitrogen amounts and fractions in legume-grass pasture systems four years after sod-seeding?

G. Issah [a*], J. Schoenau [a], H. A. Lardner [b] and J. D. Knight [a]

[a] Department of Soil Science, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK, S7N 5A8, Canada.

[b] Department of Animal and Poultry Science, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK, S7N 5A8, Canada.

[*] Corresponding author: gazali.issah@usask.ca.

Introduction of non-bloat legume species like cicer milkvetch (*Astragalus cicer* L.) and sainfoin (*Onobrychis viciifolia* Scop.) into an old and degraded pasture via sod-seeding can improve forage quality and pasture productivity. However, the impacts on soil carbon (C) and nitrogen (N) fractions are unknown. This study was conducted to determine the effects of introducing cicer milkvetch and sainfoin into a twenty-year-old degraded pasture in the Black soil zone in east-central Saskatchewan on C and N amounts and fractions four years following rejuvenation. Soils were sampled up to a 100-cm depth in the spring of 2017, 2018, and 2019 and fall 2019. Total soil organic C (SOC), inorganic N, dissolved organic C (DOC), total dissolved N (TDN), light fraction organic C (LFOC), and N (LFON) were analyzed at varying depths. Additional soil samples (0-10 cm) were collected in spring 2017 and fall 2019 for microbial biomass C (MBC) and N (MBN). Following the rejuvenation, only nitrate (NO_3^-) concentration was affected by legume species. However, soil depth, landscape position, and sampling year were significant controlling factors on C and N amounts and fractions. Introduction of cicer milkvetch and sainfoin into old and degraded alfalfa-bromegrass pastures through sod-seeding does not appear to affect soil C and N forms and amounts in the short-term.

Improved understanding of carbon dioxide net ecosystem exchange induced by crop diversification and the use of cover crops.

Jacob F. Evansa,*, Claudia Wagner-Riddlea, Shannon E. Browna

a School of Environmental Sciences, University of Guelph, 50 Stone Road East, Guelph N1G2W1, Ontario, Canada

Abstract

Carbon dioxide (CO_2), a key greenhouse gas, accounts for 77% of total greenhouse gas emissions. One of the proposed strategies to mitigate CO_2 emission from agro-ecosystems is by increasing terrestrial uptake of CO_2 through promoting agro-ecosystem diversity. We determined the net ecosystem exchange (NEE), ecosystem respiration (Re), and gross primary production (GPP) of a simple rotation (corn–soy–soy) and a diversified rotation that included winter wheat and covercrops (corn/covercrops-soy-winter wheat/covercrops), using the eddy covariance method in a three-year study from 2018 to 2020. Total annual NEE of the simple rotation compared to the diversified rotation showed a net CO_2 exchange of -183 g C m^{-2} vs. -200 g C m^{-2}, 31 g C m^{-2} vs. 31 g C m^{-2}, and -45 g C m^{-2} vs. -148 g C m^{-2} in 2018, 2019 and 2020, respectively. Averaged GPP for the three years indicated that the diverse rotation increased peak uptake of CO_2 1.3 times (-547 g C m^{-2}), compared to simple rotation (-419 g C m^{-2}). Mean annual Re for the simple rotations emitted 440 g C m^{-2}, while the diverse systems emitted 352 g C m^{-2} by the end of the 3-year study period. Taking account of the carbon removed at harvest, the net ecosystem carbon balance averaged over the three years of study came to 274 g C m^{-2} for simple rotations, and to 246 g C m^{-2} for diverse rotations.

Natural climate solution for Canada – Highlighting shelterbelts, agroforestry, wetlands and their potential to store carbon

Akhter F.[1], Soolanayakanahally R.[1], Thevathasan N.[2], Jayasundara S.[2], Drever C.R.[3]

[1]Agriculture and Agri-Food Canada, Indian Head, SK, Canada

[2] University of Guelph, Guelph ON, Canada.

[3] Nature United, Ottawa ON, Canada

Corresponding author: Fardausi Akhter, fardausi.akhter@canada.ca

Canada contributes significantly to world food production, but this has not occurred without environmental costs. The agro-ecosystem fragmentations and associated habitat destruction for monoculture production have contributed to a reduction of essential ecosystem services, such as carbon sequestration and refuge for beneficial insects and other wildlife. In central Canada, rising temperatures are linked to an increase in multiple-day precipitation events and recent large floods that have affected critical agricultural areas. To prevent further damage in Canada and beyond, we need to increase removals of carbon dioxide from the atmosphere, as well as reduce emissions from fossil fuels and land sector activities. We estimated the mitigation potential of 24 natural climate solutions related to the protection, management, and restoration of natural systems that can also deliver numerous co-benefits, such as improved soil productivity, clean air and water, and conservation of biodiversity. Natural climate solutions can provide up to 78.2 Tg CO_2e/yr of mitigation annually in 2030 (37.4 and 15.5 Tg CO_2e/yr in agriculture and wetlands, respectively) and 394.4 Tg CO_2e between 2021-2030. The mitigation identified here represents an important potential contribution or complement to Canada's commitments under the Paris Agreement, such that natural climate solutions combined with existing mitigation plans could help Canada to meet and exceed its climate goals. In this meeting, we will highlight shelterbelts, agroforestry, and wetlands related pathways and their potential to store carbon.

Soil carbon storage in prairie pothole wetlands

Chantel Chizen[1]*, Jeremy Kiss[1], Angela Bedard-Haughn[1]

[1] Soil Science, University of Saskatchewan, Saskatoon, SK

* corresponding author: chantel.chizen@usask.ca

Wetlands are important terrestrial carbon sinks but estimates often generalize that all wetlands store similar amounts of carbon. In the Prairie Pothole Region, depressional wetlands known as prairie potholes are found across the landscape. The objective of this study is to refine estimates of soil carbon storage in prairie pothole wetlands by considering climate regime (soil zone), land-use, management history, wetland classification, and soil salinity. A wetland survey was conducted across three sites in Saskatchewan: Swift Current, St. Denis National Wildlife Reserve, and Smith Creek. These sites are found in the Brown, Dark Brown, and Black soil zones, respectively. At each sampling point, electromagnetic conductivity data was collected using an EM-38 and a soil profile description was recorded. Soil samples were collected up to a depth of 90 cm with a 5.4 cm inner diameter core. The soil core was divided into five depth increments (0-15, 15-30, 30-45, 45-60, and 60-90 cm) and analyzed for total carbon, organic carbon, inorganic carbon, total nitrogen, phosphorus, pH, electrical conductivity, and sodium adsorption ratio. The differences in wetland soil carbon will be assessed with soil zone, land-use, management history, wetland classification, salinity, and depth. The data from this survey will contribute to the calculation of region-specific SOC wetland stocks for the PPR. The improved estimates of how much SOC is stored in wetlands within the PPR will play a key role in provincial policy development for wetland conservation and environmental carbon management.

Accumulation and transport of pedogenic carbonates in wollastonite-amended agricultural soils: a microplot for long-term geochemical modeling verification

Reza Khalidy*, Fatima Haque, Yi Wai Chiang, Rafael M. Santos+
School of Engineering, University of Guelph, Guelph, Ontario, Canada
*Presenting author; +Corresponding author.

The carbonation of calcium- and magnesium-silicates is a proven method for storing CO_2 to combat climate change. This approach's effectiveness, in a form known as enhanced rock weathering (ERW), has been demonstrated in agricultural and urban soils around the world by applying comminuted forms of several mineral rocks, such as dolerite, olivine, and basalt. However, these minerals' slow weathering rates make it cumbersome to experimentally evaluate long-term accumulation and transport (to the subsoil and underlying aquifer) of the sequestered carbon. This study is part of a long-term research on pedogenic carbonate formation in topsoil and its migration over time to the subsoil, which is being undertaken in a dedicated field microplot in Woodstock, Ontario, amended with wollastonite ($CaSiO_3$). Such experimental data is critical for validating reactive transport geochemical models. Our group's previous research highlighted wollastonite's comparatively high CO_2 uptake in sandy loam soil (up to 0.08 $kg_{CO2}·m^{-2}·month^{-1}$).
This presentation will provide details on the design of the field microplot, the methodology developed to assess the CO_2 sequestration and mineral weathering quantitatively, and the data collected after one year of weathering. A high dosage of wollastonite (15 $tonne·hectare^{-1}$) was applied to a 10m x 20m area that was sown with winter rye in October 2019. Topsoil and subsoil (A, B, and C horizons, down to 1.0m depth) were sampled in September 2020. Soils were analyzed by calcimetry, X-ray diffraction, SEM-EDS, and ICP-MS to determine inorganic carbon content, detect silicates and carbonates, find visual evidence of mineral weathering, and trace the movement of alkaline earth metals, respectively. It was estimated that 6.96 ± 2.71 $tonne_{CO2}·hectare^{-1}$ was sequestered in the topsoil in this period (net, compared to a control plot). Future sampling campaigns will include carbon isotope analysis to distinguish newly formed carbonates from pre-existing natural carbonates, which is especially critical in the C horizon and fields that use limestone/dolomite soil amendment. We will use our multi-year experimental data for the verification of our reactive transport model being developed using The Geochemist's Workbench.

Stable soil carbon deficits beneath woody perennial crops of the Okanagan: a regional study

David Emde[1], Andrew Midwood[1], Kirsten Hannam[2], Melanie Jones[1]

[1]Biology Department, University of British Columbia- Okanagan, Kelowna, BC

[2] Agriculture & Agri-Food Canada, Summerland, BC

In order to successfully reduce atmospheric CO_2 through enhanced soil carbon sequestration, it is essential to understand the potential of soils to store additional carbon in its most stable form. Soil carbon appears to be most stable when complexed to the surface of minerals in the silt and clay fraction. Being able to estimate the additional storage capacity of soil C in this form at a regional scale is useful in developing mitigation strategies. Previous studies have demonstrated that measurement proxies for the surface area of soil minerals provide a useful indicator of the soils overall capacity to store carbon as mineral associated organic matter (MAOM). Using soils collected from 99 orchards and vineyards across the Okanagan Valley, BC, we used both Random Forest and Stepwise Multiple Regression with AIC to develop a best fit model for predicting MAOM concentrations using standard measurements of the soils' physicochemical properties, e.g., soil texture, specific surface area. A model developed using Random Forest methods was the most accurate approach for predicting MAOM (78.2% variance explained) from data on specific surface area, total soil organic carbon concentration, exchangeable calcium, exchangeable potassium, and pH. We then applied a 90th quantile regression approach, as outlined in McNally et al. (2017), to predict the MAOM deficit in our soils. We estimate that an additional 28.5 million kg of MAOM could be stored in the top 30 cm of soils across the ~8500 ha of perennial woody cropping systems in the Okanagan Valley.

Improving Ontario's modelling estimations of soil organic carbon sequestration in manure-amended croplands

Francis Durnin-Vermette[a]*, Chang Liangb[c], Doug MacDonald[c], Bao-Luo Ma[d], Tiequan Zhang[e], Paul Voroney[a], Adam Gillespie[a]

a School of Environmental Sciences, University of Guelph, Guelph, ON, Canada

b Ottawa Research and Development Centre, Agriculture and Agri-Food Canada, Central Experimental Farm, Ottawa, ON, Canada

c Pollutant Inventories and Reporting Division, Environment and Climate Change Canada, Gatineau, QC, Canada

d Ottawa Research and Development Centre, Agriculture and Agri-Food Canada, Ottawa, ON, Canada

e Harrow Research and Development Centre, Agriculture and Agri-Food Canada, Harrow, ON, Canada

*Corresponding Author. Email address: fdurninv@uoguelph.ca

Carbon sequestration reduces GHG emissions while improving soil fertility. For carbon sequestration through agriculture to be viable, accurate estimations of sequestration values are crucial in order to guide policy-making. Currently, modelled estimates fall short because manure application is not completely considered, which is a critical gap.

The main purposes of our study were 1) to assess the accuracy of soil organic carbon estimations of process-based soil carbon models (Century and RothC) which were calibrated with data from long-term manure addition experiments in Ontario, and 2) to modify these models such that they are able to fully take manure application into account when estimating carbon sequestration in Ontario's croplands.

The models' estimations for soil organic carbon sequestration were respectively calibrated and validated using data from two long-term manure addition experiments in Ottawa and Harrow. By calibrating multiple models using multiple datasets, model-specific and site-specific biases were minimized. The statistical analyses consisted of a suite of tests that assess the modelling accuracy compared to baseline measured data: the coefficient of determination (R2), root mean square error (RMSE), average relative error (ARE), and the Nash-Sutcliffe efficiency statistic (NSE).

As a result of these improved provincial estimates, Canadians will be better-informed about the greenhouse gas mitigation potential of long-term manure addition to croplands, which will help guide decisions made by policymakers as well as farmers. These improved estimates will also be reported to Canada's national greenhouse gas inventory, and will be ultimately disclosed to the UN's Intergovernmental Panel on Climate Change (IPCC) in their global GHG summary report.

Modelling soil carbon dynamics in annual and perennial agricultural systems using the Introductory Carbon Balance Model

Authors: Sarah J. Pogue[1], Roland Kröbel[1], Jayakrishnan Nair[1], Pamela Caffyn[1], Aklilu W. Alemu[1], Marcos R.C. Cordeiro[2], Benjamin Ellert[1], Mervin St. Luce[3], Reynold Lemke[4], William May[5], Miles Dyck[6], Dick Puurveen[6], Jeffrey Deurloo[1], H. Henry Janzen[1]

Affiliations:
[1] Agriculture and Agri-Food Canada, Lethbridge Research and Development Centre; [2] Department of Animal Science, University of Manitoba; [3] Agriculture and Agri-Food Canada, Swift Current Research and Development Centre; [4] Agriculture and Agri-Food Canada, Saskatoon Research and Development Centre; [5] Agriculture and Agri-Food Canada, Indian Head Research Farm (IHRF); [6] Department of Environmental Soil Science, University of Alberta

Abstract:
Annual croplands, tame/seeded pastures and natural (native) land for pasture covered approximately 37.8, 5.1 and 14.3 million hectares across Canada in 2016. The management practices adopted on these lands can affect soil carbon dynamics, leading to gains or losses in the soil carbon pool. Understanding these impacts over multi-decadal timescales is necessary to identify those practices which can be most effective in limiting soil carbon losses or maximising gains, and thus which have the most potential as climate change mitigation strategies.
In our study, we used the Introductory Carbon Balance Model (ICBM), integrated into Holos Version 4, to investigate on-farm changes in soil organic carbon (SOC) stocks in response to environmental conditions and management practices under different annual and perennial cropping systems and in cattle-grazed pastures in the Canadian prairies. The ICBM runs on an annual timestep and uses crop-specific coefficients that describe the allocation of C in the aboveground (product and residue) and belowground (roots and root exudates) plant biomass. These coefficients determine the amount of C input annually to the soil from the different plant fractions, and, consequently, the changes to the young and old (stable) soil C pools.
The ICBM has been updated to include more recent C allocation coefficients for annual crops and to add components for harvested perennial forages and grazed pastures. The model was then tested to assess model performance and uncertainty using long-term crop rotation and grazing data (for beef cattle systems) together with measured SOC values from multiple sites across Alberta, Saskatchewan and Manitoba, and to assess the potential changes in SOC under a range of environmental (e.g., climate, soil type) and management (e.g., tillage regime, fertilizer rate, grazing intensity) conditions.

The North American Project to Evaluate Soil Health Measurements

Authors: Cristine LS Morgan, Gregory Mac Bean, Shannon Cappellazzi Michael Cope, Kelsey Greub, Daniel Liptzin Charlotte Norris, Elizabet Rieke, Paul Tracy. C Wayne Honeycutt, and Wayne Honeycutt, NAPESHM Partnering Scientists

Affiliations of named authors are Soil Health Institute

A science-based, widely applicable, and universally accepted soil health evaluation program is needed because land managers must be able to assess the current state of their soils' health and monitor progress at improvement in order to optimize productivity, economic, and environmental benefits. Developing a standard measures program is hindered by the complexity of inherent soil properties, cropping systems, management practices, and climate factors which all influence interpretation. To address this complexity and develop such a program, the Soil Health Institute is partnering with scientists managing long-term agricultural research sites in the U.S.A., Canada, and Mexico that compare a soil health-promoting system with a control for at least 8 years. Thanks to the many partners who are contributing ideas, access to long-term research sites, and data toward this project, this effort will establish a context for evaluating and interpreting over 30 soil health measures and a foundation for soil health management recommendations to achieve clarity in communicating soil functions as of management. In this project, over 2000 soil samples have been collected across 124 sites. A comprehensive database of soil measurements and management has been created along with indices to quantify the management and aid in statistical analyses. The measures and their ability to indicate soil ecosystem function in the agricultural landscape, regarding C cycling, N cycling, and water cycling as a result of changing management practices will be presented along with a vision for continued partnerships and analyses.

Acidification from nitrogen fertilization has altered phosphorus forms and cycling in long-term wheat plots in Swift Current, Saskatchewan

Barbara Cade-Menun[1] and Luke D. Bainard[1,2]

[1]Swift Current Research and Development Centre, Agriculture and Agri-Food Canada, Swift Current, SK, S9H 3X2

[2]Agassiz Research and Development Centre, Agriculture and Agri-Food Canada, Agassiz, BC, V0M 1A0

Soil acidification from high rates of nitrogen (N) fertilization is recognized as a significant problem in many countries, altering many aspects of soil health. However, new research suggests that this is also a problem for soils receiving lower rates of ammonium-N (NH_4-N) over long time periods, including on the North American Great Plains. Soil phosphorus (P) cycling is particularly vulnerable to acidification, because P is optimally soluble in soils within a limited pH range. This study used long-term plots from continuous wheat plots in Saskatchewan Canada to determine the effects of N and P fertilization or cessation on soil P cycling. The +N+P and -N+P plots were established in 1967, while subplots of +N-P and -N-P were established in 1995 by stopping P fertilization. Nitrogen was added to the +N plots at ~50 kg ha^{-1} as ammonium nitrate from 1967-2007 and as urea since 2008, while P was added as ammonium phosphate (~5-10 kg N ha^{-1}). Long-term NH_4-N addition produced a pH change equivalent to 0.5 pH units per 1000 kg NH_4-N ha^{-1}; in 2016, pH in water ranged from 5.6 (+N+P) to 6.7 (-N-P). This pH change altered aspects of both the biology and chemistry in these soils, and both N and P addition or withdrawal altered soil P cycling. Acidification affected exchangeable cations, and shifted P pools from calcium phosphates (-N-P) to aluminium and iron phosphates (+N+P, +N-P). Phosphorus addition or withdrawal significantly affected soil test P (Olsen, Mehlich) and soil total P, while soil pH and P addition/withdrawal affected soil organic P concentrations and phosphatase activities. These results indicate that soil acidification from long-term N fertilization, even at low input rates, will have significant effects on soil P availability and solubility.

Key words: acidification, N and P fertilization, phosphorus cycling, phosphorus fertilizer, phosphorus speciation

The Glenlea Long-term Rotation Study

Sarah Wilcott[1] and Martin Entz[2]

[1]Department of Soil Science, University of Manitoba, Winnipeg, Manitoba, Canada

[2] Department of Plant Science, University of Manitoba, Winnipeg, Manitoba, Canada

Presenting author: Sarah Wilcott, sarah.wilcott@umanitoba.ca

The Glenlea Rotation study began in 1992 and is the oldest study of organic cropping systems in Canada. Currently, there is a grain-only rotation (flax-oat-soybean/hairy vetch [organic]-wheat), and a forage-grain rotation (flax-alfalfa-alfalfa-wheat), which are grown under conventional and organic management. The original plots were split so that the rotations are now fully phased—all crops grown every year—and three Prairie grass plots serve as ecological benchmarks. With long-term studies, issues may be revealed that were not obvious over the short-term. At the Glenlea Rotation, the productivity of the forage-grain rotation collapsed after 8 years, due to the constant removal of P from the alfalfa hay. These issues provide opportunities to correct problems and prevent them in the future. It was also found that green manure in 1 of 4 years did not supply sufficient N to the other crops in the organic rotation. This led to further study of green manure systems in organic grain cropping to overcome N deficiency. Several tools have been developed from this study, including a green manure bioassay to detect a potential P deficiency in soils, and a nutrient budgeting tool that calculates the nutrient imports and exports on farms. These tools assist farmers and agronomists with calculating the nutrient movement on organic farms. Over the past 30 years, this study has provided invaluable information for organic farmers and agronomists and research opportunities for many graduate students and researchers from the university, as well as the wider scientific community. As we move forward, the Glenlea Rotation will be an important place to study the resiliency of organic systems and the impacts of climate change on agriculture.

Effect on microbial networks in soils from short- and long-term applications of biosolids

G. W. Price, S. Yurgel, M. Langille

Soil microbiomes are influenced by a range of agricultural activities, including from tillage, intensive cropping, and application of soil amendments. A long-term research site in Nova Scotia receiving alkaline treated biosolids over a >10-year period were evaluated for bacterial community structure using high-throughput sequencing. The research site had received biosolids applications at four different rates continuously for the entire study period, while some plots only received these rate applications once. Annual ATB applications at the highest rates had low bacterial and fungal alpha-diversity but one-time applications and low rates of ATB had higher alpha -diversity relative to the control. Using co-occurrence network analysis, it was determined that high rates of annually applied ATB had a reduced number of network interactions, average number of neighbors, and network density compared to control. This suggests that high rate and frequency of applications may have caused the microbiome to transition to a more fragile adapted state. The presentation will focus on the outcomes of this analysis and some of the possible long-term effects on soil ecosystems that receive frequent soil amendments.

90 years of agriculture on a Grey Luvisol: Management effects on soil health.

Zhang, Jingyu[1]

Dyck, Miles*[1]

Quideau, Sylvie[1]

Puurveen, Dick[1]

[1]Department of Renewable Resources, University of Alberta, Edmonton, AB T6G2R3

*correspondence: mdyck@ualberta.ca

The Breton Plots participated in the North American project to evaluate soil health measurements (NAPESHM). Long-term (>30 years) crop rotations at the Breton Plots include: 1) wheat-fallow (2-year); 2) 5-year cereal-forage; 3) continuous cereal; 4) continuous forage; and 5) 8-year cereal-legume-forage. For the WF 2- and 5-year rotations, there are also 8 fertility treatments. In the spring of 2019, Soil Health Institute personnel samples representative plots from each rotation. A comprehensive set of chemical, biological and physical soil health indicators were measured on these samples. At the end of the 2020 growing season, the same plots were re-sampled for measurement of the full soil water characteristic curve (SWCC), phospholipid fatty acid (PLFA) profile, size distribution of water-stable aggregates and distribution of light fraction C & N, ^{13}C and ^{15}N within each size class of water-stable aggregates. This presentation summarizes the effects of long-term management (rotation, fertilizer and manure applications) on the covariance of soil health indicators and agricultural productivity. Preliminary results suggest that soil health and productive can be managed with crop rotation and nutrient applications.

Towards Understanding Soil Health in Ontario Part I: Experimental Design and Land Management Data

Authors: Nicole Rabe[1], Christopher Blackford[1], Daniel Saurette[1,2], and Jim Warren[1,2]

[1]Ontario Ministry of Agriculture Food and Rural Affairs, 1 Stone Road West, 3rd Floor SE Guelph, Ontario N1G 4Y2. [2]School of Environmental Sciences, University of Guelph, Guelph, Ontario, N1G 2W1

In 2019, the Ontario Agricultural Topsoil Sampling Program was initiated to quantify soil physical, chemical and biological properties and to understand the effects of management practices on key properties of soil health across the agricultural regions on Ontario. The project is a collaborative effort with Soils@Guelph faculty, who perform specialized analyses, which seeks to develop a baseline dataset for soil health on working farms. Five hundred agricultural fields were selected using the conditioned Latin hypercube sampling algorithm based on topographic characteristics (e.g., elevation, slope, wetness index), land use (AAFC Crop Inventory), and soil (series) information to ensure optimal stratification across cropping systems and physical site characteristics, of which 269 have been sampled to date. At each selected field, three locations were sampled to represent different slope positions. Cropping system data and soil management practices were documented using landowner surveys to better understand how soil management decisions affect soil health. Most farms sampled to date were in the field crops sector (corn, soybean, wheat), an expected trend given nearly 6.5 million acres of field crops produced in Ontario annually. The next largest group of farms sampled were those with livestock in the system (i.e., pasture and forages in the system). Most farms in annual crop production (98%) used a crop rotation, however, 33% of these farms used fewer than three crops in their rotation (27% two crops, 5% single crop). Less than half of the sampled farms in annual crop production confirmed the use of cover crops (42%) as a best management practice, which is an increase from that reported in the 2016 agricultural census (25%). The use of organic amendments was confirmed at 55% of the sample locations, with about half of this in annual crop systems and half in pasture and forage systems. Lastly, a key factor known to affect management decisions is land ownership. Initial results indicate less use of organic amendments and cover crops on rented land.

Towards Understanding Soil Health in Ontario Part II: Initial Findings and Future Work

Authors: Christopher Blackford[1], Nicole Rabe[1], Daniel Saurette[1,2], and Jim Warren[1,2]

[1]Ontario Ministry of Agriculture Food and Rural Affairs, 1 Stone Road West, 3rd Floor SE Guelph, Ontario N1G 4Y2. [2]School of Environmental Sciences, University of Guelph, Guelph, Ontario, N1G 2W1

The Ontario Agricultural Topsoil Sampling Program completed to date provides a preliminary initial baseline dataset for understanding soil health in Ontario and has revealed some interesting interactions between soil/crop management practices and soil health indicators. We summarize our findings across a diversity of cropping systems in Ontario and focus on how organic matter (OM), cation exchange capacity (CEC), and bulk density are influenced by soil texture, crop rotation, landscape position, and soil management practices such as the use of organic amendments. We compare on-farm metrics of soil health to targets outlined in the New Horizons: Soil Health and Conservation Strategy for Ontario, as a goal setting mechanism for stakeholders. Across all textural groups, the majority of farms sampled had OM content below the recommended targets, reinforcing the fact that OM levels in Ontario soils are lower than desired and improvements are necessary. When looking across cropping systems, OM was statistically different only when comparing annual cropping systems (single crop and 2- or 3-year rotations) with cropping systems that included forages (annual crops + forage, pasture and forages). Topsoil layer (Ap) thickness was affected by slope position, with lower slope positions having significantly thicker topsoil (29.8 cm) than upper (24.9 cm), mid (26.4 cm) or level (24.8 cm) slope positions. The use of organic amendments in annual cropping systems did not correspond to significant changes in OM (increase of 0.4%) or CEC (increase of 1.1 cmol+/kg), or bulk density (increase of 0.01 g/cm3). We end with a discussion of future work under this sampling program and how this project is a good fit for longer term monitoring programs in Ontario.

4R Practices for Nitrous Oxide Emission and Carbon Footprint Reduction of Crop Production

Claudia Wagner-Riddle
School of Environmental Sciences, University of Guelph, Guelph, Ontario, Canada

Agricultural soils are a significant anthropogenic source of nitrous oxide (N_2O), a trace gas that contributes to the enhanced greenhouse effect and stratospheric ozone destruction. Nitrous oxide emissions associated with nitrogen fertilizer addition comprise a significant component of the carbon footprint of crop production. Managing nitrogen fertilizer following the 4R efforts to reduce the

Canada's agricultural GHG emissions inventory: Monitoring the impacts of nitrogen management

J.D. MacDonald, B.C. Liang, A. Thiagarajan, C. Flemming

Environment and Climate Change Canada

Incorporation of 4R Practices in Greenhouse Gas Inventories

Stephen M. Ogle, Department of Ecosystem Science and Sustainability and Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523, USA

Soil nitrous oxide (N_2O) emissions from agricultural soil management is a key source of greenhouse gas (GHG) emissions in many countries, and is largely driven by N fertilization practices. The 4R nutrient management paradigm provides an opportunity to mitigate emissions from this source, by reducing the rate of N application, changing the source of the fertilizer, altering the timing of fertilization, or modifying the placement of fertilizer. These practices may reduce N_2O emissions by enhancing the amount of N uptake by the crop, and thereby limiting microbial transformations of N through nitrification and denitrification. However, the influence of 4R practices needs to be incorporated into GHG inventories in order to capture the influence of 4R practices in GHG reporting and monitoring programs. Inventories are conducted using a variety of methods ranging from simple empirical approaches to complex simulation models. Empirical methods typically involve adjustments to base emission rates using scaling factors that are estimated from experimental data. For example, nitrification inhibitors and slow-release fertilizers have been empirically estimated to reduce emissions by 33-46% and 20-38%, respectively. The disadvantage to empirical methods is that they do not necessarily provide an inference on emission reductions from farms throughout the domain of interest for the inventory, particularly given the small number of studies available for deriving the empirical factors. In contrast, process-based models incorporate 4R practices by representing the influence that they have on processes, such as plant N uptake, microbial N transformations, nitrate leaching and other related processes. Process-based models can be more generalizable if the models adequately represent the influence of 4R practices on the processes. Nitrification inhibitors, for example, will reduce the rates of nitrification, potentially increase N uptake by the crop, reduce nitrate leaching and limit N_2O emissions. The DayCent ecosystem model is an example of a process-based model that has been developed to represent some of the key management options associated with the 4R paradigm. As with empirical approaches, experimental or other measurement data are needed to parameterize and evaluate process-based models. Countries or other entities could develop a measurement network to parameterize models that incorporate 4R practices, and provide an accurate estimation of N_2O emissions for reporting and monitoring of emission reductions.

Impact of nitrogen fertilizer rate on soil carbon and soil nitrogen: evidence from a 10-year trial

Joshua Nasielski*, Allison Bailey, Ken Janovicek, Kamal Banger, John Sulik, Caleb Niemeyer, and Bill Deen
Department of Plant Agriculture, University of Guelph, Ontario, Canada
*nasielsk@uoguelph.ca

The long-term effect of fertilizer nitrogen (N) on soil carbon storage and turnover has important implications for cropping system productivity and climate change mitigation. Corn is a major recipient of N fertilizer, and most of Canada's corn is grown in Ontario. To understand the impacts of N fertilizer on soil properties in an Ontario corn-based cropping system, a 10-year (2009-2018) study in Elora, Ontario, Canada was initiated by IPNI and the University of Guelph. Corn was grown every year and all crop management was held constant aside from the N rate applied. Plots received one of six long-term N rates ranging from 30 to 260 kg-N ha^{-1}. Soil organic carbon and total N (0-20 cm and 0-60 cm) was measured in every plot at the start and end of the study to quantify fertilizer N rate effects on these variables after 10 years. N fertilizer rate increased both grain yield and stover biomass each year of the trial. This caused large differences in carbon inputs across N rates due differing amounts of returned corn residue. Despite these differences in carbon inputs induced by N rate, no significant difference in soil organic carbon or total soil N, at any soil depth, were found after 10 years. Profitability analysis was also conducted and combined with our soil organic carbon results we conclude that within the range of highly profitable N rates which a farmer would be likely to apply (between 100 and 220 kg N ha^{-1}), there would be minimal effects on soil organic carbon long-term. The lack of soil N accumulation at higher N rates suggest that fertilizer N not used by the crop was lost to the environment, providing an environmental incentive to ensure N fertilize rate matches crop N uptake needs. Further implications of N rate and timing on soil processes will be discussed.

4R Management for Optimum Corn Yields and N Recovery Efficiencies Can Lower N_2O Emissions

Tony J. Vyn, Purdue University

Nitrogen fertilizer management decisions in corn production systems usually focus on obtaining agronomic- or economic-optimum yields. However, gaseous losses of N_2O per unit of yield, and per unit area, can then be unacceptably high. High N_2O losses have "cast a cloud" on claims of ever-improving production efficiencies made by agronomic scientists, crop consultants and farmers. But there is also good news. Considerable progress has been made in understanding the association of whole-plant N recovery efficiencies, as well as N balance, to seasonal N_2O emission losses from corn fields. Improvements in NRE have been facilitated by hybrids that take up proportionately more fertilizer N per unit N applied, and in modern hybrids that attain a higher N harvest index. Equally important are N management systems that apply N fertilizer in synchrony with maize plant N uptake, plus adjustments in plant population and the management of other nutrients to promote enhanced N uptake in both vegetative and grain filling periods. Farmers can simultaneously achieve improved N resource utilization and achieve optimum yields while lowering greenhouse gas emissions. In this presentation I will review examples of environmentally positive outcomes from 4R management from rainfed corn in the Central Corn Belt, as well as knowledge gaps in realizing further gains in N efficiencies.

The Effect of Freeze-Thaw Cycles on Nitrification Inhibitor Efficacy in Agricultural Soil

Konrad Krogstad[1], Grant Jensen[2], Mehdi Gharasoo[3], Laura Hug[4], Philippe Van Cappellen[5], and Fereidoun Rezanezhad[6]

[1]*Earth and Environmental Sciences, University of Waterloo, kjkrogst@uwaterloo.ca*

[2]*Biology, University of Waterloo, grant.jensen@uwaterloo.ca*

[3]*Earth and Environmental Sciences, University of Waterloo, mehdi.gharasoo@uwaterloo.ca*

[4]*Biology, University of Waterloo, laura.hug@uwaterloo.ca*

[5]*Earth and Environmental Sciences, University of Waterloo, pvc@uwaterloo.ca*

[6]*Earth and Environmental Sciences, University of Waterloo, frezanezhad@uwaterloo.ca*

Freeze-thaw cycles influence soil chemical, biological, and physical properties and thereby may impact carbon and nutrients export from affected soils, possibly altering soil health and nearby water quality. These impacts are relevant for agricultural soils and practices in cold regions as they are critical in governing water flows and quality within agroecosystems. Results from a previous study indicated fertilizer nitrogen is susceptible to nitrification and loss via leaching. In this study, a sacrificial soil jar batch experiment was conducted to assess the efficacy of nitrification inhibitors in fertilized agricultural soil during the non-growing season. For the experiment, jars were each filled with the same mass of sieved soil and were fertilized, fertilized with nitrification inhibitors, or left unfertilized and exposed to either a frozen condition (-10°C), thaw condition (4°C), or a freeze-thaw condition (alternating between -10°C and 4°C). Soil jars were exposed to their respective temperature condition for 6 weeks and porewater from the jars was extracted and analyzed weekly for nitrate (NO_3^-). The experiment results showed that nitrification inhibitors were effective at reducing nitrification under thaw conditions but were less effective under freeze-thaw conditions. NO_3^- concentration increases in the unfertilized jars under the freeze-thaw condition were comparable to the NO_3^- concentrations increases in the fertilized and inhibited jars. This suggests that freeze-thaw cycling enhanced N mineralization in the soil jars. Findings from this study indicate best management practices regarding Fall fertilizer application may need to account for changing winter processes.

The Fertility of Canadian Agricultural Soils as a Metric of 4R Practice

Tom Bruulsema, Chief Scientist, Plant Nutrition Canada

Soil tests reflect an important function of healthy soil, the retention of nutrients in forms available for plant uptake. Complemented by cropland nutrient balances, they reflect the stewardship of crop nutrients. The fertilizer industry supports periodic surveys of soil testing laboratories to monitor the distribution of soil test levels. In recent years, the attribute list has expanded beyond soil pH, phosphorus, and potassium to include sulfur, magnesium, chloride, zinc, and organic matter. Conducted systematically over five intervals from 2001 to 2020, the survey includes distributions of these attributes within each of the main agricultural provinces of Canada. Distributions of soil test phosphorus and potassium differ dramatically between Eastern and Western Canada, and so do the direction of their trends over time. Nutrient balances show increases in both inputs and outputs of major nutrients associated with improving crop yields. Several attributes of soil tests and nutrient balances contribute to their value as metrics of stewardship performance. They are scalable in their interpretation, from field to regional levels. They indicate risks of both deficiencies limiting crops, and surpluses of potential harm to ecosystem services. Positive trends include fewer soils at very low levels for phosphorus in the Prairie Provinces, and fewer soils at levels higher in phosphorus than necessary in Eastern Canada. Opportunities exist to draw down fertility in some areas, but also to build up soil fertility in others. On the whole these metrics show stewardship of crop nutrients improving to meet the multiple and complex goals of sustainable development.

Biological control of root rot complex of field pea and lentil using bacterial isolates antagonistic to *Aphanomyces euteiches*

Ashebir T. Godebo [a], Chris K. Yost [b,c], James J. Germida [a], and Fran L. Walley [a]

Email of the corresponding author: atg881@mail.usask.ca

[a] Department of Soil Science, University of Saskatchewan, Saskatoon, Saskatchewan, Canada

[b] Department of Biology, University of Regina, Regina, Saskatchewan, Canada

[c] Institute for Microbial Systems and Society, University of Regina, Regina, Saskatchewan, Canada

Pulse crops are essential components of crop rotations across the Canadian prairies. Field pea (*Pisum sativum* L.) and lentil (*Lens culinaris* Medikus) are the main pulse crops cultivated in western Canada. However, *Aphanomyces euteiches* and other root rot pathogens, such as *Fusarium* spp. (collectively referred to as the root rot complex) pose a significant threat to the sustainability and productivity of these two crops. To date, the management strategies for members of the root rot complex are not adequate. Our recent study identified soil bacteria such as *Pantoea agglomerans* PSV1-7, *Pseudomonas simiae* K-Hf-L9 and *Lysobacter capsici* K-Hf-H2 with biocontrol potential toward *A. euteiches*. The current study aims to investigate the biocontrol potential of these bacteria toward other members of the root rot complex and identify genetic determinants of key biocontrol mechanisms. All three biocontrol bacteria inhibited the mycelial growth of *Fusarium avenaceum* and *Fusarium oxysporum* during *in vitro* experiments. Of the three, *L. capsici* K-Hf-H2 showed the highest inhibitory activity against the most virulent *Fusarium* pathogens, *F. avenaceum*. Cell-free supernatant of *L. capsici* K-Hf-H2 inhibited the mycelial growth of *A. euteiches* in agar-well diffusion assays. Whole-genome analysis of *P. simiae* K-Hf-L9 and *L. capsici* K-Hf-H2 revealed both strains harboured genes required to interact with microorganisms, environments, and plants. Moreover, AntiSMASH analysis predicted various secondary metabolite gene clusters (PKSs and NRPSs) as possibly being responsible for biocontrol activity. The agar-well diffusion assay and AntiSMASH analysis output suggest that there is variation in the nature and mode of action of the secondary metabolite produced by the biocontrol bacteria. These findings indicate the potential use of bacterial biocontrol agents to control the root rot complex caused by *A. euteiches*, *F. avenaceum* and *F. oxysporum*.

Keywords: Aphanomyces, biocontrol mechanisms, root rot complex

Root influence soil microbial diversity and inter-kingdom interactions in different riparian land-use systems

Tolulope Mafa-Attoye[1], Kira A. Borden[2], Dasiel Obregón Alvarez[1,3], Naresh Thevathasan[1], Marney E. Isaac[4], Kari E. Dunfield[1,*]

[1] School of Environmental Sciences, University of Guelph, Guelph, Ontario N1G 2W1, Canada.

[2]Faculty of Land and Food Systems, University of British Columbia.

[3] Center for Nuclear Energy in Agriculture, University of São Paulo, Piracicaba, São Paulo 13400-970, Brazil

[4]Department of Physical & Environmental Sciences, University of Toronto Scarborough…

*corresponding author: K. Dunfield (dunfield@uoguelph.ca

Abstract

The complex interactive effects between plant roots and soil microorganisms are well described. Yet the patterns and networks of microbial taxa with or without roots is less known, especially in dynamic and transitional zones such as riparian systems where contributions to ecosystem services from plant-soil interactions are essential. To address this gap, we measured the active soil microbial communities with and without the presence of plant roots, using *in-situ* root exclusion, in undisturbed natural deciduous forests (UNF), undisturbed natural cedar dominated forests (CF), rehabilitated agroforests (RH) and perennial herbaceous grassland buffer (GRB). Amplicon-based analysis of 16S rRNA and ITS transcripts was used to evaluate the impact of roots presence or absence on the structure of potentially active soil bacterial, archaeal and fungal communities (extracted from RNA), and their interactions, with and without roots in these communities. Significant differences in bacterial but not fungal diversity was observed between plots with and without roots within each site. Network analysis illustrated the co-occurrence patterns between bacterial, fungal and archaeal communities (intra and inter kingdoms) in the presence and absence of roots, with grassland exhibiting distinct patterns in comparison to other sites. This study adds to our knowledge on the impact of plant roots on plant-microbe and microbe-microbe interactions in soils and potential implications for ecosystem processes.

Bryan Driscoll, Faculty of Land and Food Systems, The University of British Columbia, Vancouver BC V6T 1Z4 – driscoll6@gmail.com
Louis-Pierre Comeau, Agriculture and Agri-Food Canada, Fredericton, NB, E3B 4Z7
Maja Krzic, Faculty of Land and Food Systems, The University of British Columbia, Vancouver BC, V6T 1Z4
Bianca Eskelson, Faculty of Forestry, The University of British Columbia, Vancouver, BC V6T 1Z4

The effects of terraces and tile drainage as best management practices on labile soil carbon fractions, greenhouse gas emissions

Potato production in Atlantic Canada (AC) requires intensive management, including numerous tillage operations, often resulting in soil degradation and heightened erosion as water runoff. Potato fields in AC have been experiencing declining soil health for decades and must now face weather variability and extreme weather event pressures from climate change. To address these challenges and to conserve soil and water resources in this region, there is a need for improvement and innovation regarding current Best Management Practices (BMPs). In 2018 a new system of BMPs – named the Landscape Integrated Soil and Water Conservation (LISWC) system – was constructed at a site in Fredericton, New Brunswick. The system combines the following four BMPs: diversion terraces, grassed waterway systems, water and suspended sediment structures, and tile drainage, that are typically studied on their own. The fundamental purpose of the LISWC system is to alter the water regime in the field, which could, in turn, affect soil properties. Our study is part of this long-term project and will contribute to understanding the effects of this altered water regime.

Our study consists of 3 land management practices: natural; diversion terrace and grassed waterway; and diversion terrace, grassed waterway, and tile drainage. The study objectives are to evaluate the effects of these management practices on greenhouse gas fluxes from the soil and labile soil carbon fractions. Carbon dioxide, methane, and nitrous oxide emissions will be measured during 2020 and 2021 using an infrared gas analyzer in the field and with gas chromatography on samples taken from closed chambers. Permanganate-oxidizable carbon and light fraction organic matter are included in the study, since they tend to provide relatively quick responses to management practices, indicating changes to soil organic matter levels. Data for greenhouse gas emissions, permanganate-oxidizable carbon, and light fraction organic matter will be presented. Findings of this research will contribute to strengthening the resilience and sustainability of the potato industry in Atlantic Canada.

Aquatic dispersal of non-native earthworms in northern Canada

Stephen M. A. Paterson[1*], Aaron J. Bell[2, 3], Iain D. Phillips[2, 3], Erin K. Cameron[1]

1. Department of Environmental Science, Saint Mary's University, Halifax, NS, Canada
2. Biology Department, University of Saskatchewan, Saskatoon, SK, Canada
3. Troutreach Saskatchewan, Saskatoon, SK, Canada

* Stephen.paterson@smu.ca

With few exceptions, Canadian ecosystems support no native earthworms. Non-native lumbricid species were introduced with the arrival of European settlers and have since become widespread. Their introduction to previously earthworm-free forests can initiate ecological cascades that negatively affect ecosystem function, nutrient cycling, and biodiversity.

To mitigate impacts of non-native earthworms it is necessary to understand their means of dispersal. Most introduced earthworm species have poor natural dispersal ability and depend on human transportation for long-distance dispersal. The extent of dispersal through lakes and rivers is unclear. The objective of this study is to determine the importance of aquatic dispersal in facilitating the spread of non-native earthworms in northern Canada.

Lac La Ronge is a large lake in northern Saskatchewan that hosts over a thousand islands that vary in size, isolation, human visitation, and presence of non-native earthworms. Preliminary surveys in 2020 determined non-native earthworms to be present on 21 of 33 islands sampled and 57% of those with earthworms had no human infrastructure. These results suggest that, while non-native earthworms were likely introduced to the region by human activity, they may be achieving jump dispersal by means of aquatic transportation.

In 2021 we will expand our sampling to include over 100 islands. Earthworm species distributions and habitat suitability will be determined with field surveys. Island isolation metrics and cabin locations will be determined using GIS. Bayesian logistic regression models will be used to identify metrics that best explain distributions of earthworms. If non-native earthworms are dispersing to islands by human transportation, we expect that their presence will be best explained by presence of cabins. If they are dispersing through water, we expect their presence to be explained by island size and isolation metrics.

Improved understanding of aquatic dispersal of non-native earthworm species will inform management strategies by identifying species with the greatest invasive potential and regions at risk of invasion.

Impacts of burn severity on fungal communities and soil carbon pools in dry Douglas-fir forests

TJ Philpott and G Danyagri

British Columbia Ministry of Forests, Lands and Natural Resource Operations

200-640 Borland Street, Williams Lake, B.C., Canada V2G 4T1

Dry interior Douglas-fir forests in southern British Columbia are naturally adapted to frequent stand maintaining fires, but fire suppression and climate change have increased the severity and frequency of fires in recent years. Indeed, the 2017 and 2018 wildfire seasons in British Columbia were the largest on record, with over 1.2 and 1.3 million ha burned, respectively. Wildfire recovery, both from a carbon and timber perspective, are now key management objectives for many fire-affected ecosystems across British Columbia. However, the impacts of wildfire on soil carbon storage, and on fungal communities that regulate soil carbon dynamics, are poorly characterized. Here, we examined the response of fungal communities, soil carbon storage, and soil chemistry across a range of burn severities to identify key taxa that drive soil carbon dynamics in post-fire Douglas-fir ecosystems.

Tracking microbial gene abundances in soils over eight years of biosolids applications to agricultural soils

G. W. Price, L. Phillips

We analyzed soil nutrient parameters in samples from a long-term research field receiving alkaline treated biosolids since 2009 and correlated them with abundance of functional marker genes. Marker genes for carbon, nitrogen, and phosphorus turnover including amoA, amoB, narG, nirK, npr, apr, nxrA, urease, cu-laccase, cbh, and phoD were determined from soils over the period from 2009 to 2016. A trend over years was observed in most marker genes in soils receiving annual applications of biosolids and based on a shift in cropping from continuous corn to barley. The marker gene abundances were correlated with soil parameters using PCA to identify important clustering with specific treatment, management, and cropping group types. The goal of this analysis was to evaluate the influence of management on the soil microbiome associated with frequency and rates of biosolids application and determine how long the perceived benefits to specific nutrient cycling pathways persisted after a single application. Using archived air-dried soils was determined to be an opportunity to examine their role as indicators to track a soil's capacity to perform certain processes (such as organic matter decomposition) over time under different conditions of stress or disturbance. Results indicated that the most significant effects were from soils receiving annually applied biosolids at different rates but moderate lingering effects were observed in the one-time biosolid application treatments at the higher rates.

Carbon Loss in Surface Runoff and Tile Drainage from a Clay Loam Soil under 53 Years of Consistent Agricultural Management

X.M. Yang, C.F. Drury, W.D. Reynolds, and M. Reeb
Harrow Research and Development Research Centre, Agriculture and Agri-Food Canada, Harrow, ON N0R 1G0, Canada (xueming.yang@canada.ca)

It is well established that surface runoff (SR) and tile drainage (TD) are major pathways for pollution of water resources by agricultural nutrients and chemicals. Rather little is known, however, of the pathways and amounts of carbon (C) entry into water resources from agriculture. This paper quantifies dissolved organic carbon (DOC) and dissolved inorganic carbon (DIC) in SR and TD from a Brookston clay loam soil under 53 years of monoculture maize (*Zea mays* L.), continuous bluegrass sod, and an alfalfa-alfalfa-maize-oat rotation. Most SR and TD occurred during the non-growing season (November-April), and varied greatly among cropping treatments. About 29% of annual precipitation (836 mm) was lost via SR and TD from the four-crop rotation and monoculture maize, while only 10% was lost from continuous sod. Tile drainage accounted for 66-81% of water loss from rotation and continuous sod, but only 13% of water loss from monoculture maize. On an annual basis, 64-71 kg C ha^{-1} was lost from rotation and continuous sod, while only 47 kg C ha^{-1} was lost from monoculture maize. Forty-six % of lost C was in the form of DOC for rotation, 50% for monoculture maize, and 43% for continuous sod. TD accounted for 93% and 79% of DOC loss from continuous sod and rotation, respectively, but only 26% of DOC loss from monoculture maize. It was concluded that Brookston clay loam under 53 years of alfalfa-alfalfa-maize-oat rotation, monoculture maize and continuous sod induced strong partitioning of water flow, DOC loss, and DIC loss between surface runoff and tile drainage.

Filling in the Missing Pieces: Using Pedotransfer Functions and Machine Learning Techniques to Augment British Columbia's Soil Data Repository

A. Arbor[1], B. Heung[2], J. Zhang[1,2], C. Bulmer[3], D. Filatow[4], M. Schmidt[1], B. Kasraei[1], F. Chen[2]

Affiliations:

1. Department of Plant, Food, and Environmental Sciences, Dalhousie University. Truro, NS, B2N 5E3
2. Department of Geography, Simon Fraser University. Burnaby, BC, V5A 1S6
3. British Columbia Ministry of Forests, Lands, Natural Resource Operations, and Rural Development
4. British Columbia Ministry of Environment & Climate Change Solutions

Estimating the organic carbon stocks of BC soils through digital soil mapping is an endeavor that requires the completion of multiple intermediate steps. The BC SOIL 2020 repository, compiled through the harmonization of existing soil surveys and sampling studies, will be used as one of those intermediate steps – the use of pedotransfer functions to estimate missing soil attribute values. Legacy soil data is often missing various attribute values, as it comes from sources that vary over time and purpose but is nevertheless a valuable resource that can be leveraged to use with newer predictive modelling methods. For this project, 28,392 soil sites are available for use. To improve the final output of carbon stock estimates, applying the best pedotransfer function to estimate necessary variables is important. A commonly estimated variable in the dataset is bulk density, which is highly correlated with soil organic carbon. Other target attributes for pedotransfer functions include soil organic carbon and soil texture. A literature search was performed, to find and catalogue existing pedotransfer functions that might be applicable to the project dataset. Input variables for these include pH, percentages of sand, silt and clay, horizon depth and thickness, soil organic carbon, soil organic matter, soil structure, coarse fragment content, water content, horizon designation, textural class, and cation exchange capacity. The pedotransfer functions found in the literature will be tested and their accuracy compared with pedotransfer functions developed using machine learning methods. Potential machine learning methods include stepwise linear regression, Cubist model trees, Random Forest, support vector machines with radial basis expansion, and stochastic gradient boosting machines.

Corresponding author: Adrienne Arbor (aarbor@sfu.ca)

Exploring the Variability and Dynamics of Soil Hydromorphism in Riparian Buffer Systems using Electromagnetic Induction

Authors: Komathy Prapagar, Richard J. Heck, Naresh V Thevathasan, Asim Biswas
School of Environmental Sciences University of Guelph, Guelph, Ontario, N1G 2W1.
Email-kprapaga@uoguelph.ca

ABSTRACT

Soil redox (Eh) behaviour is fundamental in developing hydromorphic features such as gleying and mottling. Riparian zones are characterized by fluctuating soil moisture levels; consequently, the soils can exhibit considerable variability in soil redox conditions. As such, soil hydromorphism can vary with time and space. Soil hydromorphism can be quantified in terms of Fe oxides since gleying and mottling are related to Fe oxide transition and reprecipitation. The EM-38 in-phase (IP) measurements reflect the Fe oxides. The aim of the study was to evaluate the feasibility of Geonic EM-38 to quantify the variability and dynamics of soil hydromorphism in three different riparian buffer systems (RBSs): namely: i) a grass buffer system (GR), ii) a natural forest buffer system (UNF), and iii) a 'rehabilitated' tree buffer system (RH) located in Washington Creek, Southern Ontario, Canada. In each site, an in-situ field survey was conducted using Geonic EM-38 every two weeks from April to October 2019. The apparent electrical conductivity (EC) and apparent magnetic susceptibility measurements (MS) were measured at seven locations (1 m, 2 m, 3 m, 4 m, 6 m, 8 m and 10 m) from the stream edge. The field data were subjected to analyzed for 2 depths: 0-25 cm and 25-50 cm. Spatial variability of soil MS and EC were observed along with the distance and depths. Mean soil EC noticeably differed at different distances in the UNF and GR; however, RH had a minimal spatial variation of soil EC. Topsoil had higher EC fluctuation than the subsoil in all the riparian buffer systems. Mean soil MS markedly differed at distances in the UNF for both depths, and topsoil in the RH, while GR had less degree of spatial variation of mean soil MS for both depths. Different degree of soil MS dynamics was observed at each sampling points in the UNF for both depths. The MS dynamics not markedly differed at distance levels in the GR and RH for both depths. The current study findings suggest that soil redox condition can be variable with time and space in the riparian buffer soils, which is reflected by soil MS. Among the RBSs, UNF soil believes to be more sensitive to seasonal precipitation of soil moisture levels; therefore, it may depict unstable soil hydromorphism.

Hierarchical Clustering of Soil Profile Horizons: A Tool for Data Analysis in Soil classification

Lacayo, J.
Department of Basic Land Studies, National Institute for Innovation and Transfer in Agricultural Technology, Cartago, Costa Rica.

The analysis of soil profile data for their taxonomic classification tends to be very complex as the number of variables increases. This generates in some cases inadequate relationships of the data in question, which result in unsuitable classifications of the soils under study or the omission of understanding the interactions between the collected data. On many occasions, the similarity between horizons of the same soil profile is defined based predominantly on their morphological characteristics since they are the most obvious to the eye, leaving in the background the data and interrelationships resulting from laboratory analyzes, such as chemical and physical properties. That is why this work aims to determine the potential of using hierarchical algorithms that can decipher the hierarchy implicit in the data, so that it is a companionship tool in the soil classification process by compressing the data and their interrelationships. As the number of variables analyzed increases.

An agglomerative type conglomerate analysis was carried out for the horizons of the soil profiles 016Ccal and 077Lcal, located in Costa Rica, the districts of Cóbano and Lepanto respectively. The variables evaluated to carry out the cluster analysis were the relative contents of sand, silt, clay, the apparent density and the contents of calcium, magnesium, potassium and organic matter. To perform the cluster analysis, the R programming environment was used, using the Rstudio development interface. In the analysis, the Euclidean measure was used as a metric of distance between observations and the Ward link function, to compare the similarities between the horizons of each profile and proceed to carry out the preliminary groupings. Said groupings suggested by the algorithm were analyzed by graphing dendrograms for each of the soil profiles under study. Once the analysis of the groups suggested by the algorithm was carried out through the dendrogram, the horizons of the 016 Ccal profile were divided into three final groupings, generating the following groupings for this profile: Group one contains the Ap and ABt horizons, while group two contains only the Bt1 horizon. For its part, group three was made up of the Bt2, BCt1 and BCt2 horizons. The 077Lcal profile was also agglomerated in three final groupings, where the Ap and Bw1 horizon are found in the first group. On the other hand, group two is personalized by the grouping of the horizon Ab1 and Bw2. Finally, in group three, the Ab2 and Bw3 horizons were grouped. These groupings were evaluated by internal validation through the Silhouette measure. For the 016 Ccal profile, the Silhouette index for groups one, two and three were 0.27, 0.00 and 0.38 respectively, while the general average value was 0.28. For its part, the 077Lcal profile obtained a Silhouette measure of 0.15, 0.21 and 0.38 for group one, two and three respectively. The general average index for this profile was 0.25.

In both profiles, low values were obtained in the internal validation, which could indicate that the algorithm was not fully capable of understanding the levels of hierarchy present in the data. However, the analysis of the

016Ccal profile generated important results by showing that the pedon of this profile is composed of the Ap horizon and the ABt, which could change the taxonomic classification parameters for this soil. For its part, the 077Lcal profile generated important results to which, the suggestion of not taking the Ap and Bw1 horizons, as the reference epipedon and endopedon do not seem to have the same pedogenetic origin and therefore, it would be more convenient to take the epipedon and endopedon as horizons Ab1 and Bw2 which could generate changes in the taxonomic classification for this soil.

Mapping Land Suitability in Areas with Scarce Ground Data Using Homosoils Method

Qudratullah Rahmati and Joann K. Whalen
Department of Natural Resource Sciences, Macdonald Campus of McGill University

Abstract

Land suitability maps consider many factors like soil properties, topography, vegetative cover, climate, and hydrology. Soil properties are a vital indicator of agricultural potential across landscapes, but field-scale soil heterogeneity is seldom described in land suitability maps. Knowledge of climate, physiography and parent material should allow for spatial extrapolation of soil properties between sparsely distributed observations. The objective of our study is to evaluate the Homosoils methods to describe soil properties in a region that has relatively data-rich and data-poor areas. The region covers the provinces of Razavi Khorasan, Iran (35.1020° N, 59.1042° E) and Herat, Afghanistan (34.1769° N, 61.7006° E). Soil homology was assumed for the data-rich area of Razavi Khorasan province (176 observations of soil properties) and the data-poor Herat province (32 observations of soil properties). Climatic information (solar radiation, rainfall, temperature, and evapo-transpiration) was obtained from WorldClim (worlclim.org), while physiography of the region (elevation, slope, and compound topographic index) was derived from HYDRO1k. Parent material was deduced from the USGS geology maps at a scale of 1:250000. We will present a map of soil properties generated with the Homosoils method, describe the uncertainty associated with this map, and discuss the possibility of the Homosoils method to extrapolate soil properties for land suitability maps in regions with scarce ground data.

Effects of surfactants Tween-80 and Triton X-100 and colder temperatures on cow manure bioremediation of hydrocarbon-contaminated soil

Mano Krishnapillai, Ashley Locke, and Natalie Parsons
School of Science and the Environment, Grenfell Campus, Memorial University of Newfoundland
Corresponding author: mkrishna@grenfell.mun.ca

Abstract

Remediating hydrocarbon-contaminated soils using organic amendments have been gaining importance in recent times. Various agricultural wastes like crop residues and manures have been tested for removal of oil from contaminated soils. One of the issues that makes the removal of oil especially on fine textured soils is that both clays and organic matter adsorb oil on their surface and make them unavailable to microbes for bioremediation. Surfactants have the ability to dissolve hydrocarbon present and may make them available for bioremediation. This study aims at using two commercially available surfactants Tween-80 and Triton X-100 to determine their enhancing effect on bioremediation of hydrocarbon-contaminate soil using cow manure.

The objective of this experiment was to determine how the level of bioremediation of petroleum hydrocarbon (motor oil) differs based on the presence of different surfactants and colder temperatures. A laboratory experiment was conducted with one oil contamination level, one manure amendment level, two surfactant treatments, three temperatures, one control and three replicates, giving a total of 24 units. Total petroleum hydrocarbon in the soil was measured every 30 days for 120 days using a Soxtec apparatus.

Both surfactants enhanced the release of motor oil during the first 60 days than in control. However, the bioremediation rate increased only after 30 days. Surfactants acted to release motor oil regardless of the colder temperatures. However, the rate of bioremediation decreased with decreasing temperatures and the beneficial effect of surfactants was nullified when the temperature was 12^{o}C.

Rebuilding the Fertility and Productivity of Eroded Knoll Soils in South-Central Saskatchewan

Ryan Hangs and Jeff Schoenau

Dept. of Soil Science, University of Saskatchewan, Saskatoon, SK

Historical erosion (water, wind, and tillage) of upper-slope knolls within hummocky fields have typically resulted in the translocation of native fertile topsoil to lower-slope positions, leaving soils remaining at these higher landscape positions with low organic matter and poor fertility. Limited work has been done to examine the effect of fertilization and amendment strategies to rebuild phosphorus and micronutrient fertility on eroded knolls. In the spring of 2020, a three-year rotational field study was established to evaluate the productivity of spring wheat, field pea, and canola growing on two eroded knoll locations in south-central Saskatchewan with and without nine different soil fertility treatments: side-banded mono-ammonium phosphate; side-banded zinc sulfate; side-banded copper sulfate; side-banded $ZnSO_4$ + $CuSO_4$; side banded MAP + $ZnSO_4$ + $CuSO_4$; composted solid cattle manure (SCM) broadcast and incorporated; broadcast and incorporated SCM followed by side-banded $ZnSO_4$ + $CuSO_4$; side-banded Zn-containing char; and historically eroded topsoil mechanically transplanted back onto the knoll from an adjacent depressional area. The highest spring wheat yield was observed in the topsoil replacement treatment and was attributed to better soil fertility and water-holding capacity associated with the added depth of topsoil. Positive responses of wheat and pea to MAP and Zn, respectively, as well as trend towards benefit from SCM, indicate potential benefits from these amendments as well, albeit smaller than replacing the original topsoil lost by erosion. Decreased yield with Cu alone compared to Cu + MAP is consistent with previous work suggesting antagonism between P and Cu uptake by wheat under deficient soil P conditions and indicates need to consider balanced fertility in plans for reclaiming eroded knolls. The lowest yields with MAP alone and greater yields with Zn or SCM (alone and in combination) suggest Zn as a limitation to pea production on these eroded knolls. Crop growth was not affected by char alone, reflecting the small amount of char-C added (51 kg C/ha) and possible Zn-fixation reducing root access. Co-application of SCM promoted increased plant Cu and Zn uptake, indicating a positive influence of added organic matter on soil water retention, soil structure, and/or enhanced micronutrient chelation leading to greater Cu and Zn uptake. Future work includes evaluating residual treatment impacts on crop nutrient uptake and growth during 2021 and 2022.

Comparison of agri-environmental phosphorus tests in boreal agricultural and natural Podzols

Amana Jemal Kedir[1,2], David Bruce McKenzie[3], Noura Ziadi[4], Adrian Unc[1,2,5*]

Affiliations:

[1]Environmental Science Program, Memorial University of Newfoundland, St. John's, NL, Canada

[2]School of Science and the Environment, Memorial University of Newfoundland, Corner Brook, NL, Canada

[3]St. John's Research and Development Centre, Agriculture and Agri-Food Canada, 308 Brookfield Road, Building 25 St. John's, NL, Canada A1E 0B2

[4]Quebec Research and Development Centre, Agriculture and Agri-Food Canada, 2560 Hochelaga Blvd., Quebec City, QC, Canada G1V 2J3

[5]Department of Natural Resource Sciences, McGill University, Saint Anne de Bellevue, QC, Canada

[*]Corresponding author: aunc@grenfell.mun.ca

Abstract

Dozens of soil phosphorus extraction tests (P-*tests*) have been developed to quantify soil P for agri-environmental purposes. The expansion of agriculture into boreal regions dominated by Podzols requires further insights into understanding P extractability for sustainable P management. We compared the extractability of P from Podzols using ten soil P-*tests* quantified by both colorimetry and inductively coupled plasma analyses. Soil samples by depth or horizon were collected from agricultural fields and reference sites (forest or buffer-zone grasslands) in eastern, central, and western Newfoundland (Nfld) in the boreal ecozone of eastern Canada. The managed fields had distinct management and conversion histories. Soil pH, SOM, EC, cations, and P pools extracted in water, $CaCl_2$, citric acid, AB, Morgan, Olsen, Bray-1, Bray-2, Mehlich-1, Mehlich-3 were tested. Paired sample t-test comparison showed that most P-*tests* have significantly different extraction capacities regardless of the analysis methods except between water vs. $CaCl_2$, water vs. Morgan, and Olsen vs. Mehlich-3 of colorimetric analysis, and water vs. Morgan, and Bray-1 vs. Mehlich-3 of ICP analysis. The tested soil properties had inconsistent relationships ($r = 0.22$ to 0.72) with P-*tests*; also, significant correlations ($r = 0.23$ to 0.96) were detected between most P-*tests* regardless of analysis methods. A strong correlation ($r \geq 0.80$) was observed between colorimetric and ICP quantified P in citric acid, Mehlich-1, Bray-2, and Mehlich-3 extract. A linear regression with $r^2 = 0.11$ to 0.81 were established to predict the P pools extractable with water, citric acid, Olsen, Mehlich-1 and 3, and Bray-1 and 2 from standard Mehlich-3 P for both colorimetric and ICP analyses methods. For a fully informed P management for the Nfld Podzols, we recommend further *in-situ* P-*tests* calibrations against crop yields and P uptake.

Abbreviation: AB, ammonium bicarbonate diethylenetriaminepentaacetic acid; CAFD, Centre for Agriculture and Forestry Development; Col, colorimetric analysis; CR, Cormack; ICP-MS, inductively coupled plasma mass spectroscopy; Nfld, Newfoundland; NL, Newfoundland and Labrador; P-*tests*, phosphorus tests, SJRDC, St. John's Research and Development Centre of Agriculture and Agri-Food Canada.

The Influence of Long-Term Agricultural Management Practices on the Current Status of Soil Physico-Chemical Properties of a Boreal Podzolic Agricultural Soil in Cormack, Newfoundland

Natalie Parsons and Mano Krishnapillai
School of Science and the Environment, Grenfell Campus, Memorial University of Newfoundland
Corresponding author: mkrishna@grenfell.mun.ca

Abstract

Boreal Podzolic soils are highly leached, acidic, nutrient-poor, and unproductive for crop production. The cooler climate in Newfoundland causes slow rates of organic matter decomposition. Farmers use various organic amendments to make them more fertile for crop production. Long term management of agricultural land may influence the physico-chemical properties of these soils for crop production.

This study was aimed to determine the effect of over 25 years of agricultural management practices on soil physico-chemical properties as they are observed now in a boreal podzolic soil in an Agricultural farm in Cormack, Newfoundland. The 10-acre farm was in operation since 1976 and had five distinct fields which included a rotational crop field, a monocrop (potato), a long-term forage field with continuous chicken manure application, a site which had been burned with post dairy manure application. Soil sampling was done at three plots at each field site in the summer of 2020. Lab analyses were done for physico-chemical properties of soil such as bulk density, pH, electrical conductivity, organic matter content, cation exchange capacity, and nutrient contents. Results show that burned site with post dairy manure application exhibited better soil physico-chemical properties for crop production followed by rotational crop with commercial fertilizer application and long-term forage with continuous chicken manure application. Tilled mono crop field exhibited the least desirable physico-chemical characteristics for crop production. Future research should be directed toward monitoring these over long periods of time.

Developing a rapid infrared spectroscopic tool for assessment of novel lab-based soil health tests and identification of spectra patterns from Ontario soils

Andrew Hector1*, Laura Van Eerd1, Asim Biswas1, Kari Dunfield1, Adam Gillespie1
1School of Environmental Science, University of Guelph, Guelph, Ontario, Canada
*ahector@uogeulph.ca

Soil health testing has become increasingly used over the last decade with multiple organizations developing criteria or tests to better understand the physical, chemical, and biological properties of soil. Soil health tests are currently time consuming and can be expensive depending on location. This has limited the uptake of soil health testing to producers as well as limited base line soil health data acquisition across Ontario. Soil health testing is essential to evaluate best management practices (BMP) which are advocated for by the province and producer groups. To combat this gap in data we demonstrate that infrared spectroscopy, which is inexpensive and rapid, can be used to build prediction models for predicting novel lab-based soil health tests. This will provide an understanding of the BMPs which have the greatest influence on soil health indices.

Soil samples were collected (0 -15cm depth) from a long-term rotation and tillage trial. A selection of soil health tests were carried out on these soil samples, including soil organic carbon, total nitrogen, active carbon, and aggregate stability. The same soils were exposed to nearinfrared spectroscopy and, using multivariate statistics, a relationship between spectra and soil health indices was established. In addition, a correlation between spectral patterns and soil properties was determined. The project objective is to build a rapid soil health testing method using infrared spectroscopy, identify spectral patterns in soils under similar managements, and build a better understanding of soil health dynamics in regard to management practices. This work is done to increase accessibility to soil health testing and provide a means for BMP evaluation throughout Ontario, so producers and policy makers can make data driven decisions.

Soil Health Dynamics under an Intermediate Wheat Grass Perennial Forage Grain System

Nikisha Muhandiram[1*], Francis Zvomuya[1], Doug Cattani[2], Emma McGeough[3], Tim Crews[4]

[1]*Department of Soil Science, University of Manitoba, Winnipeg, Manitoba, Canada*

[2]*Department of Plant Science, University of Manitoba, Winnipeg, Manitoba, Canada*

[3]*Department of Animal Science, University of Manitoba, Winnipeg, Manitoba, Canada*

[4]*The Land Institute, Salina, Kansas, USA*

[*]*muhandin@myumanitoba.ca*

To assess the impact of agricultural practices on the resilience and diversity of food production systems, an understanding of soil performance indicators that represent optimum soil health is critical. This study examined soil health dynamics under different Intermediate Wheat Grass- (IWG-)based perennial forage treatments: IWG (a newly-bred variety) with no fertilizer post-establishment, IWG with synthetic fertilizer post establishment, IWG in a mixed stand with a legume (Alsike clover) and a single-purpose perennial crop control consisting of a 50:25:25 mix of Tall fescue/Algonquin alfalfa/Oxley II cicer milkvetch. The three-year study was laid out as a randomized complete block design with a one-way treatment structure at three small plot sites in Manitoba and Saskatchewan. Benchmark soil samples were taken prior to treatment establishment in 2019 (Year 1) for baseline soil characterization. Subsequent soil sampling (0-15 and 15-60 cm layers) was done post-establishment during the growing season in 2020 (September 2020). This presentation will focus on changes in available nitrogen (ammonium plus nitrate), available phosphorus (Olsen P), soil respiration, active C, and potentially available organic N.

Crop functional trait response to organic amendments and intercropping

Victoria Nimmo (University of Toronto – St George, victoria.nimmo@mail.utoronto.ca) and Marney E. Isaac (University of Toronto – Scarborough)

There is strong evidence supporting links between crop functional traits and predicting trait trade-offs, plant constraints, and importantly, crop yield. Understanding the causes and consequences of variation in crop functional traits – the characteristics of plants and plant parts that mechanistically drive and respond to ecosystem processes– can provide insights into critical agroecosystem processes. Over a crop's lifecycle there may also be changes to functional trait relationships as a result of changes in resource allocation tied to growth or reproductive stages. As a result of high-resource agricultural environments we may expect to see a loosening of the trait trade-offs indicating a change in resource acquisition strategies, and changes with ontogeny. Using *Triticum aestivum* as a model species, we measured a suite of leaf and root functional traits across five varietals and with various soil amendments (conventional fertilizer, organic worm castings, no amendment) and with intercropping (high and low-nodulating soybeans). We sampled the suite of traits at four intervals through a growing season in a common garden experiment. We show significant impacts of ontogeny on leaf and root functional traits across varietals and with soil amendments. This shifts in trait relationships have important consequences for nutrient uptake and nutrient loss from agricultural soils.

Examining selected soil properties on the Lower Fraser River delta following four-year grassland set-aside

M. Teresa Porter*1, Maja Krzic1, Sean M. Smukler1, Gary Bradfield2, and Drew Bondar3
1. Faculty of Land and Food Systems, 2. Department of Botany, University of British Columbia, Vancouver, BC, Unceded xʷməθkʷəy̓əm (Musqueam) Territory. 3. Delta Farmland and Wildlife Trust, Delta, BC.

The Lower Fraser River delta (LFRD) region of British Columbia encompasses some of the province's prime agricultural land. Intensive cultivation, combined with poor drainage and heavy precipitation, has led to soil degradation in the region. The Delta Farmland & Wildlife Trust (DFWT), a regional non-profit organization, provides cost-share options for the establishment of grassland set-asides (GLSA) for up to four years. A GLSA is a field that is removed from agricultural production, seeded with grasses and clover, and left to rest. The objectives of this study were to evaluate effects of four-year GLSAs on selected soil properties in the LFRD, including aggregate stability, bulk density, and aeration porosity. Samples were collected from operating farm sites in 2015, 2016, 2018, and 2019. Sites were classified as productive or unproductive, and each comprised of a GLSA seeded in 2015 and an adjacent field under annual crop rotation (ACR). At depth 0–7.5 cm, GLSA had greater aggregate stability than ACR at productive and unproductive sites after three and four years. These improvements took place in the first year of GLSA and were maintained thereafter. GLSA had lower bulk density and higher aeration porosity than ACR at depth 0–7.5 cm after three years, but not after four years. In 2018 and 2019, at depth 0–7.5 cm, aeration porosity decreased at ACR but not at GLSA. GLSA did not yield improvements in soil properties at depths below 7.5 cm, nor fully restore degraded soils. Still, GLSA remain a useful management practice for farmers in the LFRD and can improve soil quality in the first year of GLSA while protecting soil structure from further degradation in subsequent years.
Corresponding author: M. Teresa Porter, mtporter@mail.ubc.ca

Soil health and crop yields in four cropping systems transitioning to organic agriculture

Kadidia Moussa Traoré[1], Annie Brégard[1], Derek Lynch[2], Gilles Gagné[3], Julie Anne Wilkinson[3], Caroline Halde[1,*]

[1]Département de phytologie, Université Laval, Quebec City, QC, G1V 0A6, Canada; [2]Department of Plant, Food, and Environmental Sciences, Dalhousie University, Truro, NS, B2N 5E3, Canada.
[3]Centre d'expertise et de transfert en agriculture biologique et de proximité, Victoriaville, QC, G6P 2P4, Canada. * caroline.halde@fsaa.ulaval.ca

Transitioning to organic farming is a challenging step for a grain farm, as this period involves major changes in farming practices and may lead to reduced crop yields. During this three-year transition, farmers are also interested to ensure their selection of management system can maintain or improve soil health and soil carbon storage, while maintaining crop yields. The objective of this project was to evaluate the effect of different management systems on soil health, soil carbon storage, and field crop yields during the second and third years of the organic transition period. The experiment was conducted on a sandy loam soil, in Victoriaville, QC, Canada. The study site was under conventional management until the transition to organic agriculture was initiated in fall 2016. A 3-year crop rotation with barley (2017), grain corn (2018), and soybean (2019) was managed organically. The experimental units (9 m × 30 m) were arranged in a randomized complete block design, with four blocks. Four management systems with varying cover crop use, reflecting the current models of transition to organic agriculture in field cropping systems in Quebec, were compared, including conventional spring tillage with poultry manure (CT-S-M); conventional fall tillage with poultry manure (CT-F-M); conventional fall tillage without animal manure (CT-F); and reduced-tillage in the fall with composted dairy manure (RT-F-CM). The three-year transition period did not result in differences in selected indicators of soil health among the four management systems. Management systems had no effect on soil penetration resistance, aggregate stability, active carbon, and soil respiration. Soil carbon stocks were similar between management systems at 0-15 cm, but higher in RT-F-CM than in CT-F at 15-30 cm. In 2017, barley yields were higher in CT-F-M than in CT-S-M, but not different from RT-F-CM. In 2018, the lowest corn yields and grain nitrogen concentration were observed under reduced-tillage (RT-F-CM). In the third and last year of transition (2019), management systems had no impact on soybean yield. The absence of differences in selected indicators of soil health among managements systems during the organic transition may be due to each management system having a least one farming practice beneficial to soil health, such as cover crop use, animal manure, or reduced tillage.

Cover cropping influences on soil health, weed, and pest parameters, and carrot yield and quality under organic production

Francis J. Larney[1], Haley A. Catton[1], Charles M. Geddes[1], Newton Z. Lupwayi[1], Thomas A. Forge[2], Reynald L. Lemke[3], and Bobbi L. Helgason[4]

Agriculture & Agri-Food Canada, [1]Lethbridge, AB; [2]Summerland, BC; [3]Saskatoon, SK; [4]Dept. of Soil Science, Univ. of Saskatchewan, Saskatoon, SK

Cover crops play a vital role in organic farming systems, enhancing soil health and maintaining crop productivity. In southern Alberta, we evaluated seven cover crop treatments (Year 1) on weed and nematode populations, soil health parameters, and carrot yield and quality (wireworm damage, forking) [Year 2]. The cover crop treatments were: (1) fallow (no cover crop); (2) buckwheat; (3) faba bean; (4) brassica (white, brown mustard); (5) a multi-species mixture of five legumes, four grasses, two brassicas, flax, phacelia, safflower and buckwheat (15 species in total); and the multi-species mixture followed by fall-seeded (6) barley or (7) winter wheat. Cover crops were planted in June 2018, soil-incorporated by disking in August, seeded to fall covers (Treatments 6, 7 only) in September, and followed by carrot, planted in June and harvested in October 2019. There was no significant difference in weed biomass between faba bean and fallow treatments, while the multi-species mixture, brassica, and buckwheat were more competitive, showing significantly lower weed biomass. Because weed biomass was also soil-incorporated, the faba bean and fallow treatments returned greater total amounts of C to soil (2216–2221 kg ha^{-1}) than buckwheat, brassica or multi-species mixture (853–1330 kg ha^{-1}). The faba bean treatment also returned significantly more N to soil (99 kg ha^{-1}) than buckwheat (60 kg ha^{-1}), but not fallow (79 kg ha^{-1}), while both brassica and the multi-species mixture were significantly lower (37–38 kg ha^{-1} N). The multi-species mixture resulted in greater soil microbial biomass C and permanganate oxidizable C (active C) than brassica or buckwheat. However, there was some evidence that the multi-species mixture increased juicer (lower grade) carrot yield and forking. Double cover cropping (multi-species mixture followed by fall-seeded covers) led to increased wireworm damage thereby decreasing % ‘Grade A’ carrot. Cover crop treatment was non-significant for lesion nematodes, and total and ‘Grade A’ carrot yield. Results from further field trials are forthcoming to tease out the pros and cons of cover cropping strategies for irrigated organic production.

Soil health in contrasting grazing and manure treatments in Manitoba.

Author list: Stephen Crittenden1*, Terence McGonigle2, Aaron Glenn1, and Henry Wilson1.
1 Agriculture and Agri-Food Canada, Brandon, MB. 2 Brandon University, Brandon, MB.
*Corresponding author, contact at Stephen.Crittenden@Canada.ca.

Rationale and Objectives

Many soil health properties are available to producers. The utility of soil health data for on-farm management planning remains unclear. Here, we aimed to assess the ability of soil health properties to compare management practices and to assess how well soil health properties correlate with each other.

Materials and Methods

Specifically we measured pH, soil organic matter content, nitrate-N, Olsen-P, K, S, Haney P, Solvita, water extractable nitrate-N, water extractable total-N, water extractable ammonium-N, water extractable organic C, POXC, and ACE protein from a commercial laboratory. We also measured soil physical properties including soil water infiltration, soil water retention, soil wet aggregate stability, penetration resistance, and soil water content. A grazing study started in 2016 at Manitoba Beef and Forages Initiatives, north of Brandon, Manitoba, compared planned grazing, where cattle were rotated between paddocks at a stocking rate of 25 cow-calf pairs per acre per day, to conventional continuous grazing. Data were also collected from a paired watershed study at South Tobacco Creek, Manitoba, where one watershed within an arable field received solid manure every other year starting in 2013, compared to a second watershed that did not receive manure.

Conclusion

Many soil health properties were sensitive to management changes and can therefore be used to compare agronomic systems. However, correlations among similar properties i.e., organic C, Solvita, POXC and nitrate-N, total-N, and ACE protein were poor. Further regional calibration studies are necessary to understand the interrelations among soil properties if soil health packages and soil health indices are to be used.

Using 15N to Identify Spring Wheat Varieties and Traits that Improve Nitrogen Use Efficiency

Iva Henry1, Pierre Hucl1, Kate Congreves1
1Department of Plant Sciences, University of Saskatchewan
irh897@usask.ca

Abstract

Several decades of wheat breeding have provided growers with numerous high-yielding options. Wheat breeding has primarily focused on improving grain yield, but it is unknown if certain high-yielding lines are simultaneously characterized by a reduced reliance on plant nutrient inputs. Nitrogen is one of the most important inputs for wheat production, and nitrogen use efficiency (NUE) is an important quality to assess. Unfortunately, there is no recent information about which new spring wheat varieties – and associated traits – have the best NUE potential in western Canada. As such, in 2020 we initiated a 15N trial to track NUE in 25 different wheat varieties. Wheat varieties were grown in a randomized complete block design with four replications, where 15N-enriched urea was applied to central 0.5 m2 microplots. The trial was repeated at two sites (Dark Brown Chernozem) with contrasting background soil N levels. This presentation will show the results from 2020 where varietal differences were observed in grain yield, SPAD readings, NUE, and 15NUE. This project will continue in 2021 and 2022 aimed at identifying genotypes that produce high NUE and providing breeders with the information needed to create crosses with improved NUE.

Nitrogen Fertilizer Replacement Values of Summer-Seeded Legumes for Corn

Xueming Yang, Craig F. Drury, W. Dan. Reynolds

Harrow Research and Development Centre, Agriculture and Agri-Food Canada, 2585 County Road 20, Harrow, Ontario, Canada N0R 1G0 (xueming.yang@canada.ca)

Leguminous cover crops boost agro-ecological resilience and productivity through nitrogen (N) fixation, as well as other contributions, such as improvement of soil water and structure properties, reduction of erosion, runoff, and leaching, weed suppression, and interruption of pest and disease cycles. Frost-seeding red clover (RC) into wheat in soybean-winter_wheat-corn rotation can be an excellent source of N for corn in organic and conventional cropping systems; however, frost-seeding red clover becomes less popular in south Ontario due to unreliable N source from poor red clover stand and wheat yield loss from competition for nutrient and moisture with the clover. A field trail was established on heavy-textured Brookston clay loam soil in Woodslee, Ontario, to test the efficacy of selected leguminous cover crops for i) fixing nitrogen (N) and ii) providing N credit to corn. The cover crops were seeded after wheat harvest and included a crimson-white clover mix (CCWC), red clover (RC), hairy vetch (HV), and a no cover crop control (CK) . Two cover crop termination methods were used, including i) incorporating cover crop into the soil with a moldboard plow before winter and ii) chemical-burn in following spring. Grain corn was planted into: i) the chemical-burn cover crop (notill corn), ii) strip-tilled zone of chemical-burn cover crop field (strip-till corn), and iii) the field previous fall plow-down (CT corn). The urea ammonium nitrate (UAN) was used as nitrogen fertilizer with a rate 200 kg N/ha for the CK (no cover crop) and a rate of 100 kg N/ha for cover crop plots. Nitrogen fertilizer replacement value (NFRV) was estimated based on the grain yields of reduced-N-fertilized corn relative to the corn in the CK.

For termination by fall plow-down, CCWC, HV and RC fixed 144, 186 and 89 kg N/ha, respectively. For termination by herbicide burn-down in the following spring, CCWC, HV and RC fixed 142, 148 and 159 kg N/ha, respectively. Amount of fixed biomass N varied with termination time, but the RC consistently fixed less biomass N relative to CCWC and HV for the fall termination. The corn grain yields (15.5 wt. % moisture) were affected by tillage system, presence of cover crop, and cover crop type. The 3-year average yields were: fall moldboard plow (11.2 Mg/ha) > spring strip till (10.3 Mg/ha) > no-till (9.2 Mg/ha); and no cover crop (11.7 Mg/ha) > HV (10.6 Mg/ha) > RC (9.4 Mg/ha) = CCWC (9.2 Mg/ha.) A 100 kg N/ha reduction in added fertilizer N led less N deficiency in the corn grown after HV than the corn grown after CCWC and RC.

Impact of Land Use Intensity on Soil Nutrients and on Enzymes Involved in Cycling of Soil Carbon (C), Nitrogen (N) and Phosphorus (P).

Yvonne Uwituze1, 2*, Judith Nyiraneza1, Tandra D. Fraser1, Jacynthe Dessureaut-Rompré2

1Charlottetown Research & Development Centre. Agriculture and Agri-Food Canada, 440 University Avenue, Charlottetown, PEI, C1A 4N6, Canada.

2Department of Soils and Agri-Food Engineering, Université Laval, Québec, QC, G1V OA6, Canada.

*Corresponding author e-mail address: Yvonne.uwituze.1@ulaval.ca (Yvonne UWITUZE)

This two yr study evaluated how C, N and P dynamics and extracellular enzymes involved in their cycling were influenced by land use intensity at 30 sites per year from a long-term soil quality monitoring project initiated in 1998 across Prince Edward Island, Canada. Soil samples were collected in spring 2018 and 2019 for land use intensity as: 1) low (forests and continuous grasslands), 2) medium (4 yr of cereal rotations) and 3) high (2-3 yr of potato rotations). Land use intensity treatments (10 sites each x 5 sampling points per year) were compared based on total soil organic C (TOC), total N (TN), Mehlich-3-extractable P (P-M3), soil respiration and soil N supply capacity (SNS). Activities of hydrolytic enzymes (alfa-glucosidase [AG], beta-glucosidase [BG], cellobiohydrolase [CB], beta-1, -4-Nacetylglucosaminidase [NAG], leucine aminopeptidase [LAP] and phosphomonoesterase [PME] were analyzed, as well as oxidative enzymes activities (phenol oxidase [PO] and peroxidase [PP]). Results showed high values of TOC, TN, soil respiration in the low intensity sites compared to medium and high intensity in both 2018 and 2019, whereas P-M3, SNS and soil pH were higher under medium and high intensity compared with low intensity. In 2018, all land use intensities were comparable regarding all studied C cycling enzymes (AG, BG, CB and PO) except NAG and PP. The NAG activity was higher under the low intensity while PP activity was higher under medium and high intensity. Both low and medium intensity systems revealed significantly higher activity of N cycling enzyme (LAP) compared to high intensity system. The P cycling enzyme (PME) activity was significantly higher in low than in medium and high intensity systems. In 2019, the AG activity was higher under the low and high intensities while PP activity was higher under high intensity. Overall, land use intensity had an effect on soil macro- nutrients and enzyme activities, and soil enzyme activities were strongly related to soil C, N and P contents.

Key words: Carbon, extracellular soil enzymes, land use intensity, nitrogen, phosphorus, soil nitrogen supply capacity, soil respiration.

The different isotopic compositions in evaporating water and bulk soil water did not make a difference in estimated evaporative water loss

Hongxiu Wang[1,2] and Bingcheng Si[1,2,*]

[1]Department of Soil Science, University of Saskatchewan, Saskatoon SK S7N 5A8, Canada

[2]Key Laboratory of Agricultural Soil and Water Engineering in Arid and Semiarid Areas, Ministry of Education, Northwest A&F University, Yangling, Shaanxi Province 712100, China

Soil evaporation is a key process in the water cycle and can be conveniently quantified with $\delta^{2}H$ and $\delta^{18}O$ in bulk surface soil water (BW). However, recent research shows that soil water from larger pores evaporates firstly and differs from water in smaller pores in $\delta^{2}H$ and $\delta^{18}O$, which disqualifies quantification of evaporation from BW $\delta^{2}H$ and $\delta^{18}O$. We hypothesize that BW has different isotopic compositions than evaporating water (EW). Therefore, our objectives are to test the hypothesis, and to evaluate if the isotopic difference alters the calculated evaporative water loss. We measured isotopic composition in soil water in two continuous evaporation periods in a summer maize field. Period Ⅰ had a duration of 32 days following a natural precipitation event and Period Ⅱ lasted 24 days following an irrigation event with a ^{2}H-enriched water. BW was obtained by cryogenically extracting water from samples of 0-5 cm soil taken every three days; EW was derived from condensation water collected every two days on plastic film placed on soil surface. Results showed that when event water was “heavier” than pre-event BW, $\delta^{2}H$ of BW in Period Ⅱ decreased with the increase of evaporation time, indicating evaporation of heavy water; when event water was “lighter” than pre-event BW, $\delta^{2}H$ and $\delta^{18}O$ of BW in Period Ⅰ and $\delta^{18}O$ of BW in Period Ⅱ increased with increasing evaporation time, suggesting evaporation of light water. Moreover, relative to BW, EW had significantly smaller $\delta^{2}H$ and $\delta^{18}O$ in Period Ⅰ and significantly smaller $\delta^{18}O$ in Period Ⅱ ($p<0.05$). This suggests that evaporating water was close to event water, both of which were different from bulk soil water. Further, the event water may be in larger pores, from which evaporation takes precedence. We also compared soil evaporation losses derived from water isotopes of EW and BW. With a small magnitude of isotopic difference in EW and BW, the evaporation losses did not differ significantly ($p>0.05$). Our results have important implications for quantifying evaporation processes with water stable isotopes. We hope our study stimulate more researches on the effect of soil water isotopic partitioning in pore space to soil evaporation under different soil conditions and other eco-hydrological processes.

Author: Hida Manns

Session: 12 (The Soil Water Nexus)

Poster

Title: Soil pores; measuring the hole in the doughnut

Abstract

The hole of the doughnut is relevant only in the size of the total volume of dough. However, in soils, the spaces within and between the aggregates form avenues for air and water transports, along with solutes and other gases that contribute to the dynamic formation of the aggregate itself. Soil linkages are formed from the microscopic binding of sediment particles, microbial debris and decomposed plant litter in a specific order by the molecular structure of compounds, and their corresponding ionic and hydrogen bonds. The bonding gives soils their innate characteristics; ability to bond to water and other soluble nutrients, air space for oxygen circulation, hydrophobicity to block channels to preserve inner-aggregate carbon from dissolution, and to give the soil organo-mineral complexes a negative charge, thus polarizing the soil. Recent research is demonstrating that a specific size of pore is optimum for retaining carbon in the process of decomposition, and preserving a place to sequester each individual molecule. What else can soil pores tell us? And how can we explore them based on theories of physics.

SOIL DEGRADATION BY LAND USE IN THE SEMIARID REGION OF BRAZIL

Larissa Fernandes Costa1,*, Lucas Ravellys Pyrrho de Alcântara1, José Martins de França Neto1, Denizard Oresca1, Lívia Previatello da Silva1, Artur Paiva Coutinho2, Richard John Heck3, Antonio Celso Dantas Antonino1.

1. Department of Nuclear Engineering, Universidade Federal de Pernambuco, Recife, Brazil. 2. Núcleo de Tecnologia,
Universidade Federal de Pernambuco, Caruaru, Brazil. 3. School of Environmental Science, University of Guelph, Guelph, Canada.

*Corresponding author - E-mail address: larissafercosta@hotmail.com

The semiarid region in Brazil is the most populous area with this type of climate in the world. Anthropophagic activities, as the replacement of native *Caatinga* (NC) to pasture (PT), result in soil erosion and hence in desertification. Luvisols, which represents 11% of the semiarid soil in Brazil, has been greatly affected by this process. Therefore, studies of soil behavior after land use in the *Caatinga* biome are essential for understanding the causes of degradation/desertification. The aim of this study is to evaluate soil structure changes in Luvisols, comparing soil with native vegetation and soil with pasture. For that, high-resolution x-ray computed tomography was used to generate 3D images of undisturbed samples. ImageJ was used to image segmentation process in three phases: voids, matrix and rocks fragments. Images with voids phase was used to morphometric analysis and images with soil matrix phase was used to radiodensity analysis. Land use changes resulted in porosity decrease (NC=14% and PT=9.2%), interaggregate voids decrease (NC=12.7% and PT=7.8%) and almost constant intra-aggregate voids (NC=1.3% and PT=1.4%). In PT, intra-aggregate voids were smaller in size and flatten in shape. Moreover, matrix radiodensity in PT increased (NC=1677 and PT=1901). In face of that, the replacement of native vegetation to pasture in the Brazilian semiarid modified the soil structure. Decreased Interaggregate porosity, flattening of intra-aggregate voids, reduction in void size, and increased density, impaired water flux. The reduction in water infiltration and the exposure of soil exposure, by devegetation, results in more and faster runoff, and consequently greater soil erosion. Thus, the removal of native vegetation and improper soil use are causes of degradation/desertification in Brazilian semiarid.

Topography controls N_2O emissions differently during early and late corn growing season

Waqar Ashiq [1], Hiteshkumar B. Vasava [1], Uttam Ghimire [2], Prasad Daggupati [2] and Asim Biswas [1,*]

[1] School of Environmental Sciences, University of Guelph, Guelph, ON N1G2W1, Canada

[2] School of Engineering, University of Guelph, Guelph, ON N1G2W1, Canada

Abstract: Topography affects soil hydrological, pedological, and biochemical processes and may influence nitrous oxide (N_2O) emissions into the atmosphere. While N_2O emissions from agricultural fields are mainly measured at plot scale and on flat topography, intrafield topographical and crop growth variability alter soil processes and might impact N_2O emissions. The objective of this study was to examine the impact of topographical variations on crop growth period dependent soil N_2O emissions at the field scale. A field experiment was conducted at two agricultural farms (Baggs farm; BF and Research North; RN) with undulating topography. Dominant slope positions (upper, middle, lower and toeslope) were identified based on elevation difference. Soil and gas samples were collected from four replicated locations within each slope position over the whole corn growing season (May–October 2019) to measure soil physio-chemical properties and N_2O emissions. The N_2O emissions at BF ranged from -0.27 ± 0.42 to 255 ± 105 g ha^{-1} d^{-1}. Higher cumulative emissions were observed from the upper slope (1040 ± 487 g ha^{-1}) during early growing season and from the toeslope (371 ± 157 g ha^{-1}) during the late growing season with limited variations during the mid growing season. Similarly, at RN farm, (emissions ranged from -0.50 ± 0.83 to 70 ± 15 g ha^{-1} d^{-1}), the upper slope had higher cumulative emissions during early (576 ± 132 g ha^{-1}) and mid (271 ± 51 g ha^{-1}) growing season, whereas no impact of slope positions was observed during late growing season. Topography controlled soil and environmental properties differently at different crop growth periods; thus, intrafield variability must be considered in estimating N_2O emissions and emission factor calculation from agricultural fields. However, due to large spatial variations in N_2O emissions, further explorations into site-specific analysis of individual soil properties and their impact on N_2O emissions using multiyear data might help to understand and identify hotspots of N_2O emissions.

Keywords: climate change; greenhouse gases; spatiotemporal variation of nitrous oxide; crop growth; elevation; slope

Purpose: Poster presentation (student competition)

Presenter: Waqar Ashiq (washiq@uoguelph.ca), Ph.D. Candidate

***** Correspondence: biswas@uoguelph.ca; Tel.: +1-519-824-4120 (ext. 54249); Fax: +1-519-837-0756

Title: The biological sink of atmospheric H_2 is more sensitive to spatial variation of microbial diversity than N_2O and CO_2 emissions

Authors: Xavier Baril[1], Audrey-Anne Durand[1], Narin Srei[1], Steve Lamothe[2], Caroline Provost[2], Claude Guertin[1], Kari Dunfield[3], Philippe Constant[1]

[1]*INRS Armand-Frappier Santé Biotechnologie Research Centre, 531 boul. des Prairies, Laval, Québec, Canada H7V 1B7* : xavier.baril@inrs.ca

[2]*CRAM Centre de recherche agroalimentaire de Mirabel 9850, rue de Belle-Rivière, Mirabel, Québec, Canada J7N 2X8*

[3]School of Environmental Sciences, University of Guelph, Guelph, Ontario, Canada N1G 2W1

Abstract:

Above ground and below ground diversities have been suggested as important factors to enhance ecosystem service delivery. However, the relationship between soil microbial diversity and agroecosystem functioning is not clear. A field trial was established to test the hypothesis that enhanced crop diversity with the integration of winter cover crops (WCC) in a conventional maize-soy rotation promotes the biological sink of H_2 in soil and reduces N_2O emissions to the atmosphere. *Vicia villosa*, *Avena sativa*, and *Raphanus sativus* were cultivated alone or in combinations in 24 plots organized in a randomized block design. Flux measurements were performed in summertime 2019 and 2020. Soil acted as a net sink for H_2 and as a net source for CO_2 and N_2O. WCC treatments did not explain fluxes variation amongst plots. H_2 flux displayed a significant spatial variation with soil uptake rates observed in the most productive area two-fold greater than the baseline level. PCR amplicon sequencing of taxonomic and functional genes were integrated to relate variation of trace gas fluxes with compositional changes of soil microbial communities. Principal Component Analysis (PCA) identified genes distinguishing the most alpha diversity amongst the plots. Coordinates of samples in the reduced space of the PCA were used to elaborate composite alpha diversity indexes. Linear regression models were parameterized with each composite variable to explain trace gas flux variations amongst plots. Only the second dimension of the Simpson-1 index composite was meaningful. For H_2, that composite alpha diversity index explained 19 and 20% fluxes variation in 2019 and 2020, respectively. Plots displaying the highest effective number of dominant bacterial species displayed highest H_2 uptake rates, whereas alpha diversity of H_2-oxidizing bacteria was not related to H_2 flux. Those results suggests that the fitness of this functional guild is sensitive to the compositional change of microbial communities.

Fertilizer and tillage effects on soil nitrous oxide emissions from organic cropping systems

Joannie D’Amours a *, David E. Pelster b, Gilles Gagné c, Julie Anne Wilkinson c, Martin Chantigny b, Caroline Halde a

a Département de phytologie, Université Laval, 2425 rue de l’Agriculture, Québec, QC, G1V 0A6, Canada.

b Agriculture and Agri-Food Canada, Quebec Research and Development Centre, 2560 boul. Hochelaga, Québec,
QC, G1V 2J3, Canada.

c Centre d’expertise et de transfert en agriculture biologique et de proximité, 100 rue Bernier, Victoriaville, QC, G6P
2P3, Canada.

*Corresponding author. joannie.damours.1@ulaval.ca

Direct nitrous oxide (N2O) emissions from agriculture represent 52% of the total anthropogenic N2O emissions, a gas with a global warming potential 298 times that of carbon dioxide. In 2018, agriculture accounted for 8.1% of Canada’s total anthropogenic greenhouse gas (GHG) emission, suggesting that reducing agriculture’s environmental footprint through improved management and input options is crucial if Canada is to meet its commitments under the Paris agreement. Developing a better understanding of GHG emissions from organic farming, which implements different combinations of agricultural practices, would help formulate mitigation strategies. The objective of the project was to determine how various organic cropping systems affect GHG emissions and crop yields, in Québec, Canada. Nitrogen dynamics were studied over 2 growing seasons (2019 and 2020) in a sandy loam soil, under organic management combining different crop sequences (barley-corn, soybean-wheat, corn-soybean, permanent meadow, continuous fallow), sources of fertilizers (63-230 kg N ha-1 from poultry manure, green manure, or both), and tillage intensities (conventional or reduced-tillage). Soil temperature, water content, and mineral nitrogen concentrations were evaluated for their impact on processes responsible for N2O formation in soils. Nitrous oxide emissions from organic crop production were quantified and compared using nonflow-through non-steady-state chamber methodology. Yields were determined to characterize the GHG emissions intensities of each cropping system. Preliminary results suggest that organic cropping systems with reduced-tillage and green manure use reduced N2O emissions at the area scale, but the effects on yield-scaled emissions were not consistent (increase or reduction) depending on the crop and growing season. Greater knowledge of GHG emissions from organic agriculture will contribute to the development of sustainable cropping systems promoted by agrifood policies.

How Biosolids Land Application Impacts N_2O Emissions and Nitrogen Use-Efficiency in Barley Croplands?

Carmen C. Roman-Perez[a]*, Guillermo Hernandez Ramirez[a], Len Kryzanowski[b], Dick Puurveen[a], Germar Lohstraeter[b]

[a]Department of Renewable Resources, Faculty of ALES, University of Alberta, AB

[b]Agri-Environmental Innovation Unit, Environmental Strategy and Research Section, Alberta Agriculture and Forestry, AB

*Corresponding author: romanper@ualberta.ca

Abstract

Soils are sink or source for greenhouse gas (GHG) emissions - such as N_2O, CH_4 and CO_2 - depending on management practices, weather conditions and soil properties. Out of these three GHG, N_2O is of particular importance because of its high global warming potential (GWP) of about 300 times carbon dioxide GWP, and its detrimental effect on the stratospheric ozone layer. The main source for anthropogenic N_2O emissions is agricultural soils with more than 60 %, mainly because of the application of synthetic nitrogen-based fertilizers. Biosolids are by-products from municipal wastewater treatment plants that can be beneficially managed by land application for agricultural, forestry, and land reclamation purposes. However, N_2O emissions is a concern that arise from this practice as there is a lack of information about N_2O emissions caused by biosolid applications. The objective of this study is to quantify the N_2O emissions, nitrogen use efficiency (NUE), uptake efficiency (UE), and biomass productivity of barley (*Hordeum vulgare*) for silage after biosolids application.

Fifteen treatments (including a zero-N-addition control) were arranged in a randomized complete block design with four replications during three experimental years (2017, 2018 and 2019). The types of biosolids used were mesophilic anaerobic digested (BM), alkaline stabilized (BA) and composted biosolid (BC). Urea was also used as a commercial control. Both, biosolids and urea were assessed under surface and incorporation application methods. Treatments with a mix of each biosolid and urea in a proportion of 50 % - 50 % were also evaluated. Aboveground biomass production of barley yield was quantified at the end of the growing season in dry matter basis. NUE and UE were estimated based on the difference between the N treatment and the zero-N-addition control of biomass production and nitrogen uptake, respectively.

Results indicated that incorporation increased cumulative N_2O fluxes between 15 to 21 times compared to surface applications. Treatments with BM showed higher annual N_2O cumulative emissions. Barley biomass was typically higher in treatments that combined 50 % - 50 % biosolids with urea under incorporation. Similar pattern was observed for the NUE and UE values, which were higher on the treatments with 50 % biosolids + 50 % urea, as well as in the urea-only treatments. The highest NUE value was 51 kg DM kg^{-1} N; whereas the highest UE value was 0.52 kg plant N kg^{-1} N, both of them corresponding to incorporated urea.

Key words: biosolids, soil nitrous oxide emissions, barley biomass

Exploring Applicability of Holos Version 4.0 Whole-Farm Greenhouse Gas (GHG) Emissions Model in Canadian farms

K. Barham, G. Gibbs, M. Mullen, M. Nesbitt, E. Richan, & T. Van Schaik
University of Guelph
kbarham@uoguelph.ca

As a capstone project for the University of Guelph's ENVS*4001-4002 capstone course, students have prepared this presentation for Agriculture and Agri-Food Canada (AAFC) to explore Holos Version 4.0 Whole-Farm Greenhouse Gas (GHG) Emissions Model's application in Canadian farms. The research engaged with 9 farms to collect information through a student-developed survey based on Holos Version 4.0 data points representing farm operational categories. The goal of the project is to identify both mandatory and optional input parameters from Holos Version 4.0. Furthermore, the project aims to evaluate the general user-friendliness of the model along with the ease of data acquisition for specific data points. Survey results were input into the Holos model to assess the navigation of the software and to develop an emissions and mitigation strategies report, tailored to participating farm operations. Results from each farm were analyzed to rate respondents' ease of accessibility to operational information and general feedback on the applicability of the survey questions to Canadian farms. Additionally, results yielded GHG emission data for individual farms which were further analyzed for mitigation suggestions and feasibility. To improve the usability of Holos, three major recommendations were suggested to be included in the model: the addition of mitigation strategies produced by Holos based on the results of the GHG analysis, alterations to the soil selection system, and interchangeable unit input between metric and imperial within the same farm model. We expect this research to contribute to a more user-friendly version of the model, allowing for better applicability to Canadian farm management scenarios.

Evaluating the long-term effects of biobased residues on soil organic carbon dynamics using the Century Model

Badewa E. A.1, Yeung C.C2, Whalen J. K.2 and Oelbermann, M.1

1 School of Environment, Resources & Sustainability, University of Waterloo.

2 Department of Natural Resource Sciences, McGill University.

*Corresponding author email: ebadewa@uwaterloo.ca

Abstract:

Recycling of waste from the biobased production chain into agricultural lands known as biobased residues approach have the capacity to maintain SOC stocks. However, due to the variation in materials and methods of their production, the capacity of various biobased residues such as composted food waste (compost), LysteGro biosolid slurry (biosolid) and liquid anaerobic digestate (digestate) have not been fully explored. The objective of this study was to evaluate the long-term impact of mineral fertilizer versus biobased residues on SOC - active, slow and passive fractions under continuous cropping and crop rotation agricultural management practices using the Century model. Results showed that after 150 years, management practices with compost and biosolid contribute significantly ($p < 0.05$) to SOC and its fractions compared to that of mineral fertilizer and digestate that behaved similarly. Generally, SOC increased for the continuous cropping management practices (6 -35 %) compared to the crop rotation management practices (1 – 7.6 %). The SOC fractions are similar in all the management practices with an overall average of 47.3 %, 46.2 % and 6.5 % for passive, slow and active fractions, respectively. The results suggest the application of management practices with compost and biosolid can lead to an increase and stabilization of SOC in the long term compared to that of mineral fertilizer and digestate. Furthermore, the assessment emphasized the sufficiency of Century model to contribute to the agricultural soil carbon sequestrations efforts.

Keywords: active soil organic carbon, organic amendments, soil properties, agricultural management, carbon sequestration

Can increased crop yields from Canadian farmlands mitigate GHG emissions through soil C sequestration?

Arumugam Thiagarajan[2], Chang Liang[1], Douglas MacDonald[1], Darrel Cerkowniak[2]

[1]Environment and Climate Change Canada, 351 boul. St. Joseph, Gatineau, QC, J8Y 3Z5

[2]Agriculture and Agri-Food Canada, 960 Carling Avenue, Ottawa, ON K1A 0C6

Corresponding author: arumugam.thiagarajan@canada.ca

Soil organic carbon (SOC) is either a sink or source for greenhouse gases. In the past fifty years, grain yields from field crops in Canada has almost doubled. Increase in grain yields occurs in parallel with above- and below-ground crop residues, subsequently increasing amounts of crop residue carbon returned to the soil. Canada grows field crops in ~30M ha annually, and thus significant additions of crop residual carbon to soils are expected. In this study, we simulated the SOC in the 0-30-cm soil, with crop yields and residue amounts from 1976-2018 at the ecodistrict scale using the Campbell, ICBM (Holos version), IPCC Tier 2 steady state and RothC models. The initial soil carbon stocks were obtained from the CanSIS database. Monthly climate normals for each ecodistrict were used for weather inputs. Dominant soils within each ecodistricts were simulated separately. On average, carbon inputs from crop residues were 1.1 t ha^{-1} yr^{-1} in 1980 and increased to 2.1 t ha^{-1} yr^{-1} in 2018. When compared to the change in SOC (ΔSOC) values in 1990, a high degree of disparity exist among the model predictions; the predictions from the models ranged from 19-140 kg C ha^{-1} in 2005 and 64-299 kg C ha^{-1} in 2018. In general, RothC predicted the highest values and IPCC predicted the low values. When averaged across all models, the ΔSOC were 66 kg C ha^{-1} in 2005 and 299 kg C ha^{-1} in 2018 indicating a positive impact of crop productivity on the sink capacity of soils.

Response of cultivated organic soils respiration to straw and wood chips addition

KAROLANE BOURDON, JOSÉE FORTIN, JACYNTHE DESSUREAULT-ROMPRÉ, JEAN CARON
Laval University, Soil Science and Agri-Food Engineering Department, Québec City, QC, Canada

Worldwide, cultivated organic soils undergo erosion, microbial decomposition, and subsidence, leading to these highly productive lands' degradation and disappearance. Typically, from 2 to 20 t C-CO_2 ha^{-1} yr^{-1} are lost every year in cultivated organic soils through decomposition, and a similar amount is lost from wind erosion. Adding straw and wood chips is a potential strategy to compensate for these losses but requires its quantification. This study investigates soil respiration response to the input of 15 t ha^{-1} of straw and wood chips (from 6.7 to 7.0 t C ha^{-1}) and the change in soil carbon stock.

Two contrasting organic soils were tested: a highly humified soil with a low air-porosity (0.09 cm^3 cm^{-3} at -5 kPa) and a relatively low organic matter content (43%) and a less decomposed organic soil with a high air-porosity (0.35 cm^3 cm^{-3} at -5 kPa) and a high organic matter content (81%). The soils were mixed with 15 t ha^{-1} of residues in glass jars and incubated in the dark at constant temperature in a growth chamber. Soil respiration was periodically measured using alkali-traps followed by acid-base titration until cumulating 3000 degree-days, which is equivalent to one growing season in Southwestern Quebec.

The highly humified organic soil had a low basal respiration rate, cumulating approximately 0.65 t C-CO_2 ha^{-1} yr^{-1} compared to 7.5 t C-CO_2 ha^{-1} yr^{-1} for the less decomposed organic soil. This impacts the evolution in the carbon stock of the treated soils. At the end of the incubation, the highly humified soil amended with straw and wood chips had a positive carbon balance of 5.4 t C ha^{-1} (mean of all the residues), while the less humified soil had a negative carbon balance of -3.1 t C ha^{-1} despite a residue application of approximately 6.9 t C ha^{-1} for both soils. The level of soil humification seems to have a considerable influence on the decomposition dynamics of organic soils, and, as a result, it may influence the quantity of organic amendment needed to be applied to reach carbon equilibrium.

Fine-tuning the methodology for measuring soil protein

Qianyi Wu[1], Richard E. Farrell[2], and Kate A. Congreves[1]*

[1]Department of Plant Sciences, University of Saskatchewan

[2]Department of Soil Science, University of Saskatchewan

Abstract

Soil autoclaved-citrate extractable (ACE) protein is a key measure of soil health, and reliable methods for measurement are needed. Here, we evaluated two methods of soil ACE protein measurement—the Bradford and the Bicinchoninic acid (BCA) assay—and found that the BCA method produced much more reliable calibration curves. In applying the BCA method, the soil ACE protein results and measurement repeatability were influenced by certain procedural differences, namely the dilution ratio (soil extract supernatant:working reagent) and the incubation temperature/time. For best results, we recommend using a 1:8 dilution and an incubation at 37°C for 30 min prior to recording absorbance readings.

Molecular-level characterization of alkali and acid extracted soil residues using Carbon Near Edge X-ray Absorption Fine Structure spectroscopy (NEXAFS)

Jeewan Gamage, Yuki Audette, Adam Gillespie, Paul Voroney
School of Environmental Sciences, University of Guelph, Guelph, ON, N1G 2W1, Canada

The soil's capacity to retain Carbon (C) through its chemistry in binding with the solid phase has received increasing attention. Fused aromatic rings (FAR) and carboxylic-rich aliphatic (CRA) structures in soil have significant importance in the stability of recalcitrant soil organic matter (RSOM). This study provides molecular-level evidence for FAR and CRA's prevalence in the recalcitrant fraction of three (3) selected soils. In the present study, we used the alkaline extraction method and acid hydrolysis with 6M HCl in a sequence for the fractionation and Near Edge X-ray Absorption Fine Structure spectroscopy (NEXAFS) facility at the Canadian Light Source (CLS) for analyses of C functional groups at a molecular level. A muck soil having >50% of OM, a sandy Podzolic Bh horizon and a forested, calcareous Ah soil were used for the comparison.

Efficacy comparison of common acid treatments used for carbonate removal from soils without affecting their organic carbon content

Nastaran Chalabianlou1*, Paul Voroney1
1School of Environmental Sciences, University of Guelph, Guelph, Canada

Abstract
Accurate estimation of soil organic carbon (SOC) content is essential to assess its potential for C sequestration in soils in attempt to counter the progress of global warming. However, the presence of inorganic carbon in soil, mainly as calcium carbonate and dolomite, can confound measurements of organic carbon unless it is removed prior to analysis. The scientific literature suggests that methods to remove carbonates may also significantly alter analysis of SOC content. In this study we compared the efficacy of most commonly used acid treatments to remove carbonates from soils and their potential effect on measured SOC content. Treatments with HCl (1 M, 3 M, 6 M), H2SO3 2m, and H3PO4 2M were applied to calcium carbonate and the produced CO2 was trapped with NaOH in sealed containers. HCL 3 M was selected as the most efficient option with complete recovery of carbonates. These acids were evaluated for their effect on SOC and none released CO2 after treatment. Based on these results, we recommended treatment of HCL 3M for carbonate removal of soils.
Corresponding author: *nchalabi@uoguelph.ca

Soil organic carbon content decreases partly attributed to dilution by increased depth of cultivation in southern Ontario

C.J. Warren[1,2], D.D. Saurette[1,2], A.W. Gillespie[2]

[1]Ontario Ministry of Agriculture Food and Rural Affairs, 1 Stone Road West, 3rd Floor SE Guelph, Ontario N1G 4Y2. [2]School of Environmental Sciences, University of Guelph, 50 Stone Road East, Guelph, Ontario N1G 2W1

ABSTRACT

Soil organic carbon contents and depths of Ap horizons (i.e., cultivated topsoil) from Ontario soil survey reports were reviewed analyzed and compared from 1950 to 2019. Organic carbon concentrations have declined from 2.85% to 2.34% in Ap horizons while depths have increased by 40%. Considering the entire Ap horizon depth, we show that soil carbon stocks (kg C ha^{-1}) may be constant or increasing. Losses of organic carbon due to cultivation should not be discounted; however, dilution of organic carbon within a deeper plow layer may contribute significantly to observed decreases in organic carbon concentrations in topsoil.

Species identity effect on soil C storage in European forests: broadleaves (oak, beech) versus a conifer (pine).

Richard Osei1, Hugues Titeux1, Jean-Thomas Cornelis2, Quentin Ponette1
1Earth & Life Institute, Université catholique de Louvain, Louvain-la-Neuve, Belgium.
2Faculty of Land and Food Systems, University of British Columbia, Vancouver, Canada

Contrasting species identity effects on soil C makes tree species selection is a key decision for forest management aimed at enhancing soil C storage in forests. In temperate and boreal forests, species identity effects on soil C is often categorized broadly into broadleaves and conifers. Previous studies on limited sites have suggested that conifers accumulate more C in the topsoil than broadleaves, and the reverse occurs in the mineral subsoils, resulting in similar soil C stocks in the whole soil layer (topsoil + subsoil) between broadleaves and conifers. However, it is unclear whether this topsoil vs subsoil trade-off between coniferous and broadleaves occurs at large ecological scales differing in climate, topography, and edaphic factors. In this study, we used paired forest stands distributed along South-North ecological gradient in Europe (Seven countries) to compare soil C stocks and distribution between broadleaves (oak: *Quercus petraea / robur*, beech: *Fagus sylvatica*) and pine (*Pinus sylvestris*). We categorized forest floor (FF) and organo-mineral 0-10 cm as topsoil layers whiles 10-40 cm served as the mineral sub-soil layer. We used mixed effect models with species (beech, oak, pine) and covariates, stand basal area and stone content, as fixed effects while forest site was fitted as random effect. The results show more soil C stocks under pine in the topsoil than the broadleaves, as previously reported. In the mineral subsoils, there was no difference in soil C among the three species. Consequently, there was more C stocks in the total soil depth (FF+0-40 cm) under pine than the broadleaves. The results imply that, at large ecological scales in Europe, C storage in the mineral subsoil layers under beech and oak species forests could be similar to that of pine, contrary to earlier reports.

Monitoring soil organic carbon change in Saskatchewan farms from 1996 to 2018: Comparing on-farm management practices to long-term field experiments

Mervin St. Luce[1], Brian McConkey[2], Jeff Schoenau[3], Ryan Hangs[3]

[1]Swift Current Research and Development Centre, Agriculture and Agri-Food Canada, 1 Airport Road, Swift Current, SK, S9H 3X2

[2]Swift Current Research and Development Centre, Agriculture and Agri-Food Canada, 1 Airport Road, Swift Current, SK, S9H 3X2 (retired), and Viresco Solutions

[3]Department of Soil Science, University of Saskatchewan, 51 Campus Drive
Saskatoon SK, S7N 5A8

Corresponding author: Mervin St. Luce (email: mervin.stluce@canada.ca)

Abstract

Increasing soil organic carbon (SOC) storage is vital to reducing carbon dioxide from the atmosphere, and enhancing soil and environmental health. We examined how carbon (C) and nitrogen (N) within whole soils and soil organic matter (SOM) fractions in Brown Chernozem soils in the Prairie Soil Carbon Balance Project (PSCB) responded to 21 years of conservation management practices, and compared their changes to a long-term field experiment (LTFE) initiated in 1981 in the same soil zone. Soils from the PSCB were sampled in 1996 and 2018 at the 0-10, 10-20 and 20-30 cm layers, while soils from the LTFE were sampled in 1998 and 2016 at the 0-7.5, 7.5-15 and 15-30 cm layers. Soils were fractionated into particulate organic matter (POM), with mineral-associated organic matter (MAOM) determined as the difference between whole soil and POM. For the PSCB, soil total N (STN) and SOC increased by 18% and 13%, respectively, and was more pronounced in fine- than coarse-textured soils. Changes in SOM in the PSCB soils were more evident in the MAOM fraction, which increased in the 0-10, 10-20, 0-20 and 0-30 cm layers. The highest gain in SOC in the LTFE was much lower than that of the PSCB, while loss of STN was observed in the LTFE versus a gain in the PSCB. Overall, MAOM contained the majority of C and N in both studies, but their contents decreased in the LTFE compared to increases in the PSCB. These results suggest that the conservation practices likely enhanced the formation and stability of MAOM in the PSCB soils.