Agricultural, Life and Environmental Sciences
Graduate Students' Association
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ALES Graduate Research Symposium

March 24 & 25, 2022

Solving Global Problems Together

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RESEARCH ABSTRACTS

Oral presentations

Session 1 (9:15 – 10:30 AM MT, March 24, 2022)

Evaluating the impact of CCAFS CSA intervention on food security

Meghan Lim *(REES), Bruno Wichmann, Marty Luckert*

Smallholder farmers in rural regions of developing countries are often vulnerable to climate events. Climate Smart Agriculture (CSA) offers a sustainable approach to adaptation that aims to improve agricultural yields and mitigate climate change. The Consultative Group on International Agricultural Research (CGIAR) research program on Climate Change, Agriculture and Food Security (CCAFS) has made substantial investments in developing and scaling CSA programs in several developing countries. This paper uses flexible machine learning tools to estimate the impact of participating in a CCAFS CSA program on household food security. We also estimate these impacts within three sub-samples, which categorize households according to their CSA adoption strategy. Our results indicate that overall, households that participated in a CCAFS program are 6% more likely to be food secure ($p<0.05$). The food security benefits of CCAFS program participation are most clearly demonstrated among households that adopted a diverse set of CSA practices, where CCAFS training increased the probability of being food secure by 11% ($p<0.05$). On the other hand, the food security benefits of CCAFS training were negligible among households that did not adopt CSA practices or adopted a specialized set of practices.

Understanding intergenerational trauma in indigenous communities: The case of Canada and residential school

Jerico Fiestas-Flores (*REES*)

The end of residential schools in Canada in 1996 did not meant the end of their effects for indigenous populations. The impacts of these institutions might not be only present on the attendees, but also in their family members, creating problems also for the futures generations. By using the Aboriginal Peoples Surveys of 2012 and 2017, the present study builds an artificial panel data set to asses the presence of intergenerational trauma among family members whose relatives (e.g. grandparents, parents) attended residential schools. The study uses the information contain in the Aboriginal People Survey (APS) for 2012 and 2017 to apply a logistic regression to identify significant relationships in each period of time, and in order to identify the persistence of this effect over time, the I create an artificial panel data to explore if the effects persist over time. The survey allows to account for last degree of education, self reported physical health and mental health status. The results show that in both survey periods, attending, or having a relative that attended a residential school does have a negative effect on education and health. The panel data analysis confirms that these effects persist over time for those who attended the schools on educational and health outcomes, however, the magnitude of such effects are reduced when adding controls. With

respect to intergenerational effects, we find that they continue to be a problem 20 years after the program was finished, and that the effects on physical and mental health are negative and robust. These findings suggest that there is still a long way for reconciliation and that the effects of residential schools might continue affect indigenous populations in the future.

Fort Nelson First Nation-Owned Tu Deh-Kah Geothermal Project: A Case Study of Community Perceptions & Support

Sara Chitsaz *(REES), John Parkins*

In the context of increasing global emissions, there is a push for further development and adoption of renewable energy, including through local, community-led renewable energy projects. There is a growing body of academic discourse on the significance of community ownership of energy, including the distinction between equity-ownership and community buy-in. Communities in Northern BC, including Fort Nelson, often rely on fossil fuels for energy; although there are increasing opportunities for these communities to develop their own renewable energy sources. One such community initiative is the Fort Nelson First Nation (FNFN)-¬owned Tu Deh-Kah geothermal project (TDK), which will provide energy to Fort Nelson. This paper uses a community capacity theoretical framework to provide a case study of the Fort Nelson First Nation member's perceptions and attitudes toward TDK. The aim of this paper is to develop an understanding of Fort Nelson First Nation members' perceptions of and attitudes toward TDK, and to better understand the level of community support for TDK. Using original survey data from 45 participants from the FNFN supported by interview data from FNFN members and other stakeholders in TDK, this paper aims to identify the social and economic context that the geothermal project is being developed in.

Supporting Quality and Longevity in Alberta's Family Day Homes

Laura Woodman *(HECOL), Adam Galovan*

My research focuses on the strengths and challenges facing Alberta's family day home educators, and which supports they need in order to thrive and offer high-quality childcare. As most of the new licensed spaces being created across Alberta are aimed at family day homes, timing of this study is pivotal. Day homes are routinely excluded from early learning and childcare research, resulting in a significant gap of knowledge on what day educators need to succeed. This research helps fill in the gap of what is known, and its results can be used to better understand and support family day homes.

Session 2 (11:00 – 1:05 PM MT, March 24, 2022)

Characterizing the arthropod community and ground beetle diet in canola agroecosystems in central Alberta

Aldo Ríos Martínez *(AFNS), Boyd Mori*

The canola industry provides a $26 billion (CAD) yearly contribution to the Canadian economy. Canola production in the Canadian prairies is affected by a variety of introduced and native herbivorous insects. Mortality by predation is a major factor determining the population dynamics of invertebrate pests, and generalist predators have been shown to successfully suppress insect pest

populations in a variety of agricultural systems. Ground beetles (Coleoptera: Carabidae) are among the most abundant generalist predators in canola fields in the Canadian prairies. However, their diet in this agroecosystem remains undetermined. This project aims to establish a comprehensive record of the arthropod community in canola fields in central Alberta, and to investigate the trophic interactions between ground beetles and key pests in canola using DNA metabarcoding. Arthropod surveys were conducted throughout the 2021 growing season (June 2 - August 19). Nine canola fields in central Alberta were sampled weekly using yellow sticky cards, wet pitfall traps, sweep nets, and soil samples. In addition, ~ 1900 carabid specimens were live-collected and preserved at -80° C for future molecular analysis. The results from this study will fill an important knowledge gap in the literature in relation to the interactions between canola pests and their predators.

Characterization of clubroot disease symptoms in Arabidopsis using the peat-based media and partially-hydroponic assay systems

Shengjuan Li *(AFNS), Jocelyn Ozga, Harleen Kaur, Dennis Reinecke*

Clubroot disease is a serious soil-borne disease of cruciferous plants including the model species Arabidopsis thaliana, caused by pathogen Plasmodiophora brassicae. The infection causes the swelling and abnormal growth (galling) of the roots, which disrupts water and nutrient uptake, and can result in wilting, stunting, and severe yield losses in plants. To assess the progression and improve the quantification of the clubroot symptoms in the roots of Arabidopsis, plants were grown in the peat-based media and partially-hydroponic systems. Seedlings (14-d-old) were inoculated with 1x10^4 or 1x10^5 spores/mL of P. brassicae in the peat-based media. Seedlings continued to grow in the peat-based media until harvested at 25, 29, and 35 days after inoculation (DAI) or they were transferred after 7 or 14 DAI to the partially-hydroponic system where seedlings were grown on filter paper wetted with 1/4 strength Hoagland's solution in plastic bags covered with foil until harvested at 27 DAI. The P. brassicae-infected seedlings developed prominent root galls at both inoculum densities when grown in either the peat-based media or the partially-hydroponic systems. In the peat-based media, the gall formation progressed over time in the infected roots and resulted in ~ 28-43 % root length inhibition at both inoculum densities. These data suggest both the peat-based media and partially-hydroponic assay systems can be used for studying the clubroot disease symptoms in Arabidopsis.

Genome-wide association reveals the genetic basis of physiological parameters in soybean under drought stress

Dilrukshi Kombala Liyanage *(AFNS), Davoud Torkamaneh, Francois Belzile, Malinda S. Thilakarathna*

Soybean is the leading legume crop in the world. In Canada, it is the third-largest field crop in terms of farm cash receipts and its production has recently increased in the Canadian Prairies. Soybean fix atmospheric nitrogen through the symbiotic rhizobia bacteria in root nodules, where drought stress can limit growth, yield, and symbiotic nitrogen fixation in soybean. The changing global climate is predicted to lead large areas of the world to experience extensive drought conditions over the next few decades. Notably, many regions in western Canada have been experiencing frequent and severe droughts over the last few decades. Identification of drought-tolerant soybean varieties is critical for maintaining soybean production in the future. The objective

of this project is to identify the genotypic and allelic variation associated with diverse short-season soybean varieties for plant physiological parameters and water use efficiency. A greenhouse pot experiment was conducted with 106 Canadian soybean varieties to evaluate different plant physiological traits under drought stress. The soil moisture content was maintained at 80% field capacity (FC) (well-watered) and 30% FC (drought) in pots from three weeks after seeding till seed maturity. Under drought stress, soybean plants exhibited lower stomatal conductance and transpiration, leading to more water use efficiency compared to the well-watered plants at the flowering stage. The leaf chlorophyll content was also higher in drought-stressed plants compared to the well-watered plants, possibly due to nitrogen accumulation under drought stress. Significant genotypic variability among soybean varieties was found for stomatal conductance (SC), transpiration (TR), leaf chlorophyll content (LCC), water use efficiency (WUE), photosynthesis (PH), and intrinsic water use efficiency (IWUE). A genome-wide association study was performed for different plant physiological parameters for 30% and 80% FC. In total, 15 quantitative trait locus (QTL) regions were detected including PH, SC, and WUE.

Drought stress response in alfalfa and consequences to soil health parameters

Danielito Dollete *(AFNS), Rhea Lumactud, Malinda Thilakarathna*

Alfalfa (Medicago sativa L.) is an important forage legume globally due to its high yield and nutritional quality. Alfalfa forms a symbiotic relationship with nitrogen-fixing rhizobia bacteria that provide fixed nitrogen to host plants through symbiotic nitrogen fixation (SNF). Drought stress is one of the major environmental factors that negatively affect SNF, where nitrogen fixation can be severely hampered when plants are exposed to extended drought periods. We hypothesize that drought significantly affects SNF and nitrogen rhizodeposition in alfalfa, consequently affecting extracellular enzyme activities, soil microbiome, and soil nitrogen availability. A greenhouse pot experiment was conducted to evaluate the effects of drought stress on nodulation, nitrogen fixation, plant physiological parameters, and plant growth in alfalfa and their subsequent effect on soil enzyme activities, soil nitrogen availability, and soil microbial community. Alfalfa plants inoculated with Sinorhizobium meliloti Rm1021 were subjected to drought stress at the flowering stage: 20% field capacity (FC) (severe drought), 40% FC (moderate drought), and 80% FC (well-watered) for three weeks. We found that leaf chlorophyll content, nodule number, root traits (length, volume, surface area), and plant biomass (root and shoot) were significantly reduced under severe drought conditions compared to the well-watered condition. Similar trends were observed under moderate drought conditions; however, leaf chlorophyll content increased compared with the well-watered condition. The available soil nitrogen (NO_3^- + NH_4^+) was higher following three weeks of severe drought compared to the well-watered conditions. Furthermore, enzyme activity for nitrogen cycling (N-acetyl-glucosaminidase) diminished under drought conditions. However, extracellular enzymes responsible for cycling carbon (β-Glucosidase, β-D-Cellobiosidase) and phosphorous (Phosphatase) were not affected by drought stress. The effect of drought stress on SNF will be measured using the 15N-isotope dilution method, where soil microbiome analysis will be performed to investigate the effect of drought on the soil microbial community.

Preparation of transparent and thermo-reversible pea protein gels and their potential applications as gelatin alternatives

Peineng Zhu *(AFNS), Lingyun Chen*

Gelatin gel has been widely used in various food and pharmaceutical applications for its unique properties of being transparent and thermo-reversible. As the emerging market of vegan, Halal and Kosher products, much attention has been put on looking for the replacement of gelatin from plant-based ingredients. Pea protein has been one of the key ingredients in plant-based foods in recent years owing to its competent nutritional value, functionalities and low allergenicity. In our lab, we developed a thermo-reversible pea protein gel with transparent appearance from pea protein isolate extracted through ammonium sulfate precipitation method. Within a range of acidic pH (pH 2.4-4.2) and protein concentration of 10-15%, the heat-induced pea protein gel at low temperature showed thermo-reversibility with fine mechanical properties. This allows its application as gelatin alternatives in various food formulations such as yogurt, desserts, and other fermented products with mild acidic pH environment to provide texture and "melting in the mouth" sensation. With the modulation of pH value and protein concentration, gel mechanical properties and transparency can be manipulated yet still maintain its thermo-reversibility. In addition, gel thermo-reversibility was found to be stable upon repeated heating and cooling process as the gels were physically cross-linked through hydrogen bonds. This work demonstrate that the prepared pea protein gel shows high similarity to gelation gels in terms of thermo-reversible gelation and transparent appearance, which provides great potential as a substitute for gelatin in various vegan products.

Upgrading the Lipid-to-Hydrocarbon Technology to Sustainable Aviation Fuel: a route to net zero GHG emissions

Bingxin Hai *(AFNS), Justice Asomaning, David C. Bressler*

Aviation provides a rapid worldwide transpiration network. It is a fast growing industry where, by 2050, over 10 billion passengers are expected to be carried by air each year. Without any additional improvement in technology, fuels, or operations, meaning that the aviation sector remains industry reliance on fossil fuels, this intensive activity would generate nearly 2000 megatonnes of CO2 that contribute to global greenhouse gas (GHG) emissions. This forecast on GHG emissions raises public concerns about the sustainability of the aviation sector. With the increasing awareness of global warming and climate change from individuals to politics, it is necessary to deploy sustainable aviation fuels (SAF) that have been reported to reduce CO2 emissions by up to 80% over their lifecycle compared to fossil fuels. My research focuses on upgrading the Lipid-to-Hydrocarbon technology to sustainable aviation fuel with the incorporation of short-chain alkene gases at the pyrolysis stage. Various reaction parameters including reaction temperature, reaction time, and the molar ratio between a model fatty acid and a short-chain alkene gas have been investigated to leverage the reaction chemistries for the enhancement in the yield of branched hydrocarbons. This compound category is key for the production of SAF because it can reduce the freezing point of the fuel, preventing it from solidifying at high altitudes. The success of this research will heighten the application of renewable lipid-based feedstocks in SAF production, which will lead to a contribution to the global net zero emissions goal.

Hydrothermal and Cellulase Treatment for Co-production of Cellulose Nanocrystals and Fermentable Sugars

Dagem Zekaryas Haddis *(AFNS), Michael Chae, David C. Bressler*

The traditional biorefinery strategy for production of bioethanol from cellulosic material has focused on complete or nearly complete hydrolysis of cellulose to fermentable sugars. This conversion process requires high advanced cellulase cocktail loading and long reaction times to depolymerize the recalcitrant crystalline regions of cellulose to fermentable sugars. Hence, to reduce high production cost associated with high enzyme loading and long reaction times, we introduce an integrated biorefinery strategy that provides high fermentable sugars recovery while leaving the crystalline regions intact for subsequent production of cellulose nanocrystals (CNCs). First, hydrothermal treatment is employed to enhance the mobility of the cellulose molecule and facilitate the formation of new ordered crystalline regions that can increase CNC production. Next, a cellulase treatment will hydrolyze the poorly ordered amorphous chains to generate sugars that can be fermented to ethanol. With the integration of hydrothermal and enzymatic treatments of wood pulp prior to production of CNCs, glucose yields ranging from 13% to 22% and xylose yields of 2.3% to 3.7% (based on the original feedstock) were obtained over a period of 6 to 24 hours and the CNC yields for wood pulp treated for 6-hours improved by 2.3-fold as compared to CNCs yield from untreated wood pulp (based on the amount of material used for acid hydrolysis). In addition, CNCs yield based on the original feedstock improved by 1.4-fold as compared to the untreated wood pulp. Thus, the results have shown that the integration of hydrothermal and cellulase treatments facilitated recovery of fermentable sugars and improved the CNCs yield.

Genetic Engineering of Carbon Flow Arabidopsis Seeds to Accelerate Breeding for High Protein Canola

Kallum McDonald *(AFNS), Kethmi Jayawardhane, Gavin Chen*

Canola (Brassica napus L.) is the major oilseed crop in Alberta. After seed oil extraction, the protein- and cellulose-rich seed meal is primarily used as animal feed. However, an excess of cellulose (fiber) in the seed meal can inhibit digestion in monogastric livestock. There is research interest in enhancing the digestibility and nutritional value of canola meal by partial reallocation of seed carbon from cellulose to storage protein biosynthesis without penalizing the seed oil content. However, characterizing the genes involved in such carbon reallocation is time and labor intensive when done in canola directly. We propose a creating a rapid screening platform using Arabidopsis thaliana L., a fast growing relative of canola, to accelerate the genetic worked needed to reallocate seed carbon. Our strategy is three-pronged: 1) seed-specific RNAi-downregulation of Arabidopsis CELLULOSE SYNTHASE 1 (AtCESA1), 2) overexpression of B. napus DIACYLGLYCEROL ACYLTRANSFERASE 1 (BnDGAT1), and 3) overexpression of several protein biosynthesis-related genes from Arabidopsis (AtAAP1, AtUmamiT18, AtAAT1, and AtASN1) to determine whether seed carbon reallocation for effective for increasing seed protein content. We have successfully obtained AtCESA1-RNAi/BnDGAT1-overexpressing T3 lines with partially reduced seed cellulose, maintained seed oil, and maintained or increased seed protein. These findings support the effectiveness of the carbon reallocation strategy and evaluation of the protein gene-overexpressing lines is ongoing. Once complete, this rapid genetic characterization platform can be

used for fast-tracked characterization of candidate genes for developing high protein, value-added canola varieties. This platform will accelerate the fundamental genetic characterization research needed for breeders to develop canola with better nutritional properties and improved digestibility, thereby creating value for farmers, animal agriculture, and canola export market.

Investigation of the dispersal of diamondback moth (Plutella xylostella) across North America

Kanishka M. Senevirathna *(AFNS), Boyd A. Mori*

Invasive insect species can have drastic consequences on both natural and managed ecosystems. In agriculture, invasive species can cause significant damage which reduces crop yield and increases the cost of production. Diamondback moth (DBM) is considered the most destructive insect pest of the family Brassicaceae, especially cultivated Brassica spp. Due to the significant economic destruction caused by DBM, monitoring their movement as well as identifying their source populations and potential routes of invasion is the first line of defense. The use of wind trajectories, often combined with pheromone traps to capture insects, is employed to determine invasion routes and source populations of mobile pest species. This information can be used to help predict infestations and implement an integrated pest management strategy. However, determining the movement and origin of insect pests is difficult based on wind trajectories alone. Molecular studies have been employed to infer insect movements across agricultural landscapes and predict corridors that are used for insect invasions. Molecular data can also supply insight into the insecticide resistance status of pests and genes which are associated with such traits. In this study, we will use wind trajectory models combined with analysis of population genetic structure to investigate the dispersal of DBM across North America and determine if current wind trajectory models can predict the origin of Canadian populations. Moreover, we will investigate the insecticide resistance of DBM populations using bioassays adapted from the Insecticide Resistance Action Committee. This information will allow us to understand resistance in DBM in Canada, and if resistance is associated with population structure. The ultimate goal of this study is to use this knowledge to mitigate DBM damage through integrated pest management and enhance both the quality and quantity of canola production in the Canadian Prairies.

Session 3 (10:00 – 11:30 PM, March 25, 2022)

Importance of site selection for studying trace elements and fallout radionuclides

Andrii Oleksandrenko *(RENR), Sarah Lord; Tommy Noernberg, William Shotyk*

"When identifying possible atmospheric contamination by trace elements or fallout radionuclides, it is important to find a matrix that can detect and preserve the incoming level of constituents of interest. Peat bogs serve as natural archives of trace elements and fallout radionuclides. Peat bogs are ombrotrophic wetlands where the vegetation receives nutrient and contaminant inputs exclusively from the atmosphere. Due to the absence of surface and groundwater influence, peat bogs are excellent archives for analyzing the input of fallout trace elements and radionuclides from the atmosphere. The purpose of my research is to determine whether fallout radionuclides can serve as global chronostratigraphic markers of the start of the Anthropocene. The main aim of this presentation is to underline the importance of site selection for studying trace elements and fallout radionuclides in bogs.

There are two major ways to identify ombrotrophic peatlands: botanical, based on the dominant plant and moss species growing on the site, and chemical, based on the chemical composition of water (e.g. pH and concentrations of major ions). Using examples from the Mackenzie River delta region, this study addresses the importance of careful site selection, using both methods (botanical and chemical) to choose suitable bogs for this research. In addition, the importance of coring location within a given bog is demonstrated, using examples from Ontario and Germany.
On-site, ombrotrophic and minerotrophic peatlands can look similar one to another, having similar plant and moss species. However, simple pH measurements of the porewaters extracted from peat cores can clearly distinguish ombrotrophic peat bogs (pH 3.5-4.5) from minerotrophic peatlands (pH commonly 6–7). The concentration of Sr in the corresponding peat samples, and its variation with depth, provides a second approach to clearly distinguish between ombrotrophic and minerotrophic sites within the same area, as well as their botanical and chemical evolution over time."

Rare Plant Mitigation During Pipeline Construction on the Northern Great Plains

Beckett Stark *(RENR)*

Rare plant mitigation is a practice becoming increasingly utilized to balance industrial development with biodiversity outcomes. Several issues facing this emerging field of restoration ecology will be discussed including:

1) Rare plants can have cryptic life histories and distribution patterns that make monitoring their populations difficult.

2) There is no federal definition of rare plant mitigation success, and it is up to the operator and consultants to determine if their rare plant mitigation is successful.

3) Current federal best practice recommendations may not be operationally viable or ecologically necessary."

Trace elements in the acid soluble ash fraction of Sphagnum moss: Surrogate for atmospheric deposition of sub-micron aerosols within the Athabasca Bituminous Sands region

Na Chen *(RENR), Fiorella Barraza, René J. Belland, Muhammad Babar Javed, Iain Grant-Weaver, Chad W. Cuss, William Shotyk*

The Athabasca Bituminous Sands industry in Alberta has dramatic impacts on the economy of the province. Nevertheless, with increasing industrial operations, environmental concerns are also raised regarding the contamination of air and water with trace elements (TEs). To better assess the influence of the industry on the surrounding ecosystems, it is crucial to determine the TEs associated with the coarse and fine aerosols which differ in their size and chemical compositions. Here, Sphagnum mosses were used as biomonitors of atmospheric deposition, and contributions from bulk deposition and fine aerosols were estimated by determining the abundance of TEs in bulk moss and acid soluble ash (ASA). The ash content of moss clearly increased towards industry, reflecting increasing mineral dust inputs. Total concentrations of conservative, lithophile elements such as Al, Y and Th increased towards industry, along with metals found in bitumen (V, Ni, and Mo) and elements of concern (Pb, Sb, and Tl). Acid soluble concentrations of these elements (except for Mo) also showed obvious or slight increasing trends

and correlated strongly or moderately with acid soluble Y. Acid soluble proportions (acid soluble/total concentration) were high for Al, Y, V, and Ni, while low for Th, Mo, Pb, Sb, and Tl. This indicates that the former elements might be largely contributed by ultrafine clay minerals such as kaolinite and illite, while the latter by larger size minerals such as feldspar and heavy minerals (e.g., monazite, zircon) from bituminous sands. Silver and Cd, behaving more like micronutrients such as Cu and Zn, were obviously impacted by plant uptake in addition to mineral dust deposition. The study highlighted the importance and necessity to determine the chemical reactivity of TEs in dusts when evaluating their associated health risks to living organisms.

Chronic trace element toxicity of Lake Miwasin water and sediment to Daphnia magna.

Sunny Choi *(RENR), Chad Cuss, Chris Glover, Greg Goss, William Shotyk*

Lake Miwasin is a constructed pilot scale pit lake containing treated tailings from the extraction of oil from Alberta's bituminous sands. It is expected that such lakes will provide toxicity amelioration before their release. The long-term goal of this research is to understand how the hydrological and geochemical processes that occur over time in a pit lake setting will affect the bioavailability, bioaccumulation and toxicity of the trace elements in tailings and oil sands process-affected waters. The immediate objective was to determine the initial (i.e. year 1 and 2 following lake construction) toxicity of Lake Miwasin water and sediment to a model freshwater invertebrate species, Daphnia magna. Acute 48 h toxicity tests were conducted with mortality as the endpoint, and chronic 21 d toxicity tests were performed using reproduction and growth as endpoints. No mortality was observed over 48 h; however, final body masses of D. magna were significantly larger in Lake Miwasin water only treatments in the chronic tests, compared to exposures to water and sediment. Daphnid reproduction was also affected, with reduced total neonate production observed in both water and water/sediment groups relative to artificial laboratory water controls. Trace metal body burdens were also analyzed to identify trace elements that may contribute to the observed effects. Results showed exposure to Lake Miwasin water and water/sediment increased trace metal (i.e., Mo, Ni, Al, Co) burdens in daphnids. Lake Miwasin is still at an early stage and will evolve over time. Developing a better understanding of the toxicity associated with trace elements in Lake Miwasin is important for assessing the safety of future pit lakes and water releases."

AF4-ICP-MS as a powerful tool to resolve colloidal trace elements in bog waters

Yu Wang *(RENR), Chad W. Cuss, Sundas Butt, Andy Luu, Lei Pei, William Shotyk*

Thousands of tons of dust particles are deposited into the surrounding peatlands from industrial activities in the Athabasca Bituminous Sands (ABS) region. These dust particles are considered primary pollutants and the dominant source of heavy metals. Their reactive mineral fractions have the potential to dissolve in bog waters due to the low pH and abundance of organic acids, but there have been few quantitative studies. The majority of potentially toxic trace elements (TEs) in bog waters, and much of the dissolved organic carbon, are present in the form of colloids. The size and properties of these colloids determine transport, bioavailability, and overall impact of TEs on surrounding ecosystems. The challenges to analyze species in this size range include the extremely low concentrations of TEs and the complex sample matrix including abundant organic

matter and low pH. Herein, an analytical method was developed to resolve the ionic and colloidal forms of TEs in the dissolved fraction of bog waters with high precision and resolution. This was accomplished using asymmetric flow field flow fractionation (AF4) coupled to inductively coupled plasma mass spectrometry (ICP-MS). Method effectiveness and precision were demonstrated through size calibrations at the beginning and end of each day, and triplicate analyses of Suwannee River Nature Organic Matter (25 ppm C, pH=4). The RSD for size calibrations and the standard deviation of recovery for most elements were less than 5%. This approach was applied to bog surface waters and moss waters (expressed from the living layer of Sphagnum moss) collected near the ABS region. The dominant forms of TEs in bog surface waters were either ionic (ca. < 0.3 kDa, e.g., V, Mn, Ni, Zn, and As) or DOM-associated species (ca. 1.3 and 4.2 kDa, e.g., Fe, Pb, Th, and U). Moss waters showed a higher concentration and a larger size distribution ranging from 0.5 to 60 kDa. Moss waters have a much shorter reaction time than bog surface waters; therefore, these differences may be due to the incomplete dissolution of dust particles in moss waters. These findings represent a first step in assessing the potential mobility and identifying bioavailable forms of TEs in peatland waters.

Influence of Concentration and Speciation of Trace Elements in Soil Solution on Plant Uptake and Accumulation by Hordeum Jubatum L.

Dulani H. Kandage *(RENR), Chad W. Cuss, Lina Du, Tommy Noernberg, William Shotyk*

Trace elements (TEs) enter plants via two main pathways: root uptake from the soil solution and foliar uptake from material deposited on leaf surfaces. The level and rate of TE uptake through these pathways depend on number of factors associated with plant, soil, and environment. When determining the impact of soil related factors on plant uptake, it is important to account for or eliminate potential uptake via atmospheric deposition. Our study will determine the impacts of TE concentration and speciation in soil solution on plant uptake in the absence of atmospheric deposition. A pot experiment was designed using soils collected from Lake Miwasin, an engineered demonstration pit lake developed to ensure the successful integration of tailings and surrounding landscape back into the environment. Foxtail Barley (Hordeum Jubatum L.), a naturally grown, abundant plant on the Lake Miwasin landscape was used as the indicator plant. The plants were grown inside laminar flow, Class 100, metal-free clean air cabinets. The soils were spiked with three elements (Ni, V and Mo), chosen for their importance in the environment and their enrichment in bitumen. Salt solutions of Ni (5 and 25 mg/kg of soil), V (15 and 75 mg/kg of soil), and Mo (1 and 5 mg/kg of soil) were mixed with the surface soil at two concentration levels. The above ground plant biomass was harvested using ceramic scissors, and the soil solutions were collected using silicon carbide (SiC) lysimeters that have been modified and specially cleaned to facilitate trace-level measurements, in the metal-free, ultraclean SWAMP lab. The TE concentrations in digested plant samples and soil solutions will be analyzed using ICP-MS, and the distribution of TEs amongst major colloidal forms will be analyzed using AF4-ICPMS.

Keywords: Soil solution, Root uptake, Trace elements, Colloids, Bituminous Sands

Poster presentations

Integrating enhanced efficiency fertilizers and nitrogen rates to improve Canada Western Red Spring Wheat production in the Canadian prairies

Adam Fast *(AFNS), Brian Beres, Dean Spaner, Guillermo Hernandez Ramirez, Xiying Hao, Sherri Strydhorst, Greg Semach, Jessica Weber, Laurel Thompson*

Canada Western Red Spring (CWRS) wheat is the most widely grown wheat class in Western Canada. This is mainly due to its excellent milling and baking qualities, while also having a high protein content. Optimum CWRS production requires sufficient nitrogen (N) supply and is typically applied as granular urea fertilizer during planting. Problems of N loss can arise when using urea, therefore enhanced efficiency fertilizers (EEFs) have been developed. EEFs aim to maintain the integrity of applied N to increase plant nutrient uptake and reduce its loss to the environment. To determine if EEFs can improve upon conventional methods, a CWRS yield parameter experiment was established in 2019 across four locations in Alberta and two in Saskatchewan. This experiment consists of two factors: (i) N form [urea; urea + urease inhibitor (Agrotain®); urea + nitrification inhibitor (eNtrench®); urea + urease & nitrification inhibitor (SuperU®); urea + urease & nitrification inhibitor (NBPT/DMPSA); and polymer-coated urea (Environmentally Smart Nitrogen®-ESN®)], and (ii) N rate [60; 120; 180; and 240kg N ha-1]. Preliminary results indicate N form does not affect grain yield or protein content, while N rate does. N rates of 180kg N ha-1 significantly improved grain yield over 60kg N ha-1, while 120 and 240kg N ha-1 produced similar results to each group. Additionally, protein increased significantly with increasing N rate. These findings illustrate that the amount of N fertilizer applied, provides a greater impact on CWRS yield parameters than the type of N fertilizer used. Also, growers who incorporate EEFs in their CWRS production are not subject to reductions in yield parameters relative to conventional methods. Further studies are needed to determine whether EEFs are an appropriate investment for different cultivars grown in the Western Canadian climate.

Lipid-Based Renewable Fuel for the Aviation Sector

Bernardo A. Souto *(AFNS), Justice Asomaning, David C. Bressler*

The demand for the aviation sector is expected to grow considerably over the next few years. Considering that this sector remains almost entirely dependent on fossil fuels, the aviation industry is exploring the possibilities of using sustainable fuels, and developing new biojet fuel pathways is necessary. The novel Lipid-to-Hydrocarbon (LTH) technology can convert a wide range of lipid materials to drop-in fuels, using pyrolysis of fatty acids at high temperatures and pressures. Previous studies have shown that operating the LTH in the presence of light hydrocarbons results in increased branched compounds. These compounds are a class of hydrocarbons essential for jet fuels because they impact fuel properties such as lowering the freezing point, a crucial property when flying at high altitudes and cold temperatures. This research seeks to further explore and optimize the use of light hydrocarbon gases with four carbons to enhance the yield of branched compounds in the LTH technology. Initial experiments have shown four-carbon isomers have different behaviors during the pyrolysis reaction with the model fatty acid, almost doubling the yield of branched compounds when compared to an inert atmosphere. This observation can be

explained by the molecule structures, as these four-carbon molecules can exist as either a linear or branched compound. The promising results show that the mechanisms of the LTH process can be controlled by using different isomers to increase branched compounds in the pyrolysis product. These results expand the knowledge in high-temperature chemistry and present a new pathway to convert any lipid-based feedstock, from restaurant greases to agricultural wastes, to biojet fuel and concomitantly reduce the aviation sector's carbon footprint.

Efficient production of transgenic wheat plants (Triticum aestivum) using particle bombardment system.

Sandhya Gautam *(AFNS), F. Jiang, G. Chen, and J. Laurie*

Efficient production of transgenic plants has been a challenge in developing gene-edited wheat plants. Hence, different morphogenic genes, such as Baby boom (Bbm) and Wuschel (Wus), which play a vital role in plant growth and development, have been used to increase transformation efficiency in cereals. The main objective of this research was to produce an efficient transformation protocol that could be used further in our gene-editing projects using plasmids that contain these morphogenic genes and red fluorescent protein (pporRFP) as a visual marker. Immature 'fielder' embryos were collected 14 days post-anthesis, sterilized and scutella were dissected. Biolistic/particle bombardment was used as the means for plasmid delivery. The scutella were heat-stressed at three weeks post-bombardment and then, subsequently transferred to shoot and root growth media. Visual marker, RFP was tracked in every developing embryo throughout the tissue culture process. Using this approach we were able to produce transgenic wheat plants with about 20% transformation efficiency. Thus, this system could be used to deliver any gene of interest into the wheat genome and could also be helpful in many gene-editing modifications.

Evaluating Consumer and Producer Behaviour and Attitudes Surrounding Environmental Aspects of the Canadian Dairy Industry

Katherine Rogers *(REES), John Parkins, Ellen Goddard*

Across Canada, there are now approximately 3 million people that identify as Vegan or Vegetarian. Though reasons for this diet vary across individuals and groups, a major motivator found in recent research is that individuals and families are concerned about their environmental footprints and are seeking diets and lifestyles that can reduce their personal impacts on the planet. In addition to this research, scientists are looking into the ways that certain agricultural industries contribute to climate change, as well as ways for farmers to reduce their environmental impacts as a method of mitigating climate change. Specifically, the dairy industry is one that requires a variety of inputs including heat and electricity, feed and space for animals, and significant amounts of water; while creating many environmentally damaging outputs throughout the production process. Though, there are some solutions available. Through the use of genomics and selective breeding, producers are able to reduce their environmental footprint on dairy operations by selecting traits for their cattle that, for example, require less feed and produce less methane. In this research project, I analyze the ways that Canadian dairy consumers demonstrate their understandings of pro-environmental behaviors, and the ways that emotions impact their decision-making processes. Furthermore, I investigate the ways that genomic modification, through selective breeding, exist to make the dairy industry more sustainable and better for animal welfare and how Canadian

consumers respond to this science. Through the creation and distribution of a general population survey, my research includes an innovative analysis on the ties between the sociology of emotions and the Theory of Planned Behaviour in the context of Canadian dairy consumption. Exploring these concepts allows for a better understanding of the context behind current and future consumption trends, supporting dairy producers in creating products that meet the environmental and welfare expectations of consumers.

Nanocomposite Nanofibrous Membranes for Protective Clothing against Chemical and Biological Agents

Elham Kaviannasab *(HECOL), Laura Munevar-Ortiz, Md. Saiful Hoque, Patricia I. Dolez*

It is crucial to keep various occupations safe from chemical and biological hazards by utilizing protective clothing. Current solutions include a wide range of materials from air-permeable membranes combined with a sorptive material to impermeable materials and sealed clothing constructions. However, chemical/biological protection often disrupts clothing wearer's comfort. On the other hand, nanofibrous membranes offer promising prospects to develop comfortable chemical/biological protective clothing due to their high surface-area-to-volume ratio, small pore size, and breathability. Also, nanoparticles (NPs) such as magnesium oxide (MgO) and silver (Ag) can be embedded into the nanofibers to detoxify chemical and biological compounds. This thesis work assesses the protection and comfort performance of polyacrylonitrile (PAN) nanofibers embedded with MgO and Ag NPs. Test methods like the filtration efficiency against aerosols (e.g. following ASTM F2299), neutralization rate of liquid and vapor chemical agents, and antibacterial activity (e.g. following AATCC TM 100) can be used to characterize the protection function. Furthermore, air permeability, water vapor transmission rate, evaporative resistance, flexibility, and 3D bending can be used as a measure of comfort. The tensile and tear strength and the abrasion resistance provide an assessment of the membrane durability. As part of a multilayer chemical and biological protective clothing, this membrane will permit that the thermo-physiological comfort and ultimately the health of people exposed to chemical and biological hazards are not put at stake because of their protective clothing. This work is part of the Canadian Department of National Defence (DND) IDEaS COMFORTS (Comfort-Optimized Materials For Operational Resilience, Thermal-transport, and Survivability) project.

Detecting the influence of landcover factors on fire containment in the Boreal Forest Region of Alberta

Siqi Mo *(RENR), Jen Beverly*

Prior studies in the United States, Europe, and Canada have shown that variations in land cover attributes can affect where fires stop. In this study, 242 fire perimeters documented during a 9-year period (2010-2018) were examined to investigate the role of land cover attributes on the formation of fire perimeters in the Boreal Forest Region of Alberta. Land cover attributes were extracted from multiple spatial datasets including the provincial fuel map derived from the Alberta Vegetation Inventory to identify fuel types of the Canadian Forest Fire Behaviour Prediction (FBP) System, the Landsat landcover map from the Natural Resources Canada, historical harvested areas, and the Boreal Surface Water Inventory map documented in the Alberta Biodiversity Monitoring Institute (ABMI) wall-to-wall human footprint inventory. Matched case-control conditional logistic

regression was used to identify land cover attributes that had a significant influence on the formation of fire perimeters. Matched pairs of data were selected on either side of the fire perimeter to represent burned and unburned states. Spatial information associated with each data point was extracted using GIS automation in ArcGIS model builder and custom tools written in Python. Preliminary results indicated that fire perimeters are more likely to form in locations with land cover types that have less vegetation. Difference in hazardous fuel composition was significant in 6 out of 9 years. In terms of water amount and distance to water, only 3 out of 9 years was significant. And under the current circumstances, the harvested areas variable is also only significant in 1 year out of 9. However, when combining all the fires in 9 years, the results showed the harvested area variable is significant. Our results point to a strong but complex relationship between the land cover factors and containment of wildfires.

Peat extraction activities: Does the extraction phase influence the export of major chemical water quality indicators?

Mika Little-Devito *(RENR), Kevin Devito, William Shotyk*

Horticultural peat extraction is an expanding industry in Canada with the potential to negatively impact downstream water quality. Previous studies have reported increases in dissolved organic carbon (DOC) and nutrients in outflow water leaving extraction locations. Peat extraction is a multi-year process and the water quality associated with each extraction phase has yet to be quantified in Canada. Changes to the in situ physicochemical processes occurring in the peat at each phase can potentially impact the availability of nutrients, DOC, and major ions.

The objective of this study was to determine the effect of peat extraction activities on the availability and mobility of nutrients, DOC, and major ions in different extraction phases within two Alberta peatlands. Electrical conductivity (EC), pH, water level, volumetric flow rate, and chemical analyses of nutrients and DOC were assessed at undisturbed, restored, and extracted sites. The in situ ion availability was measured in shallow surface peat, alongside measures of peat physicochemical conditions: surface and below ground temperature, soil moisture, and peat aeration.

Preliminary results suggest that in situ physicochemical conditions are variable, but extraction activities do not appear to affect surface temperature, soil moisture, or aeration in the surface peat, despite lowered water tables. Recovering sites showed elevated EC and pH values compared to extracted and undisturbed locations. Extracted sites had elevated ammonium and nitrate availability, but newly extracted fields had less available nitrogen compared to mature fields. When ditches were incised into underlying mineral sediments, water quality differed from bog waters. Specifically, EC and pH values were similar to regional surface waters, suggesting that drainage ditch substrate must be considered in impact assessments, especially in terrains containing carbonate minerals. The findings from this study suggest that sites undergoing extraction are at elevated risk of nitrate leaching, but ditch substrate may determine downstream water quality.

Optimization of a real-time immunoPCR assay using polyclonal antibodies against tan spot and fusarium head blight of wheat.

Ilakkiya Thirugnanasambandam *(AFNS), Tara Vucurevich, Nat Kav, André Laroche, Jonathan Challis*

Wheat is a staple food crop with 760 million tonnes consumed globally in 2020. Canadian wheat production rose to 35 million tonnes in 2020 with the Prairie Provinces being the major producers. Airborne fungal pathogens pose a serious threat to wheat growers all over the world including Canada. Tan spot (TS), caused by Pyrenophora tritici-repentis (Died.) Drechs, and fusarium head blight (FHB), caused by Fusarium graminearum (Schwein) Petch, are important wheat diseases that impact crop quality and yield. In this study, polyclonal antibodies were validated against TS and FHB spores through indirect enzyme linked immunosorbent assay (ELISA). An indirect checkerboard ELISA was used to determine the effective specificity of polyclonal antibodies against fungal spores by using different concentrations of both antigens and antibodies. A real-time immunoPCR (RT-iPCR) assay was optimized for TS and FHB spores. The RT-iPCR assay is carried out by coating the fungal spores (antigen) in 96 well microtiter plates, then adding rabbit sera specific to the fungal spore (primary antibody), followed by secondary antibody conjugated to a DNA oligonucleotide based on the Thunder-LinkR PLUS oligo Antibody Conjugation Kit. The linear range of detection was between 50 and 750 for TS spores and between 1300 and 115,000 spores for FHB via ELISA compared to 2 and 375 for TS spores and 235 and 60,000 for FHB spores through RT-iPCR assay. RT-iPCR assay provided 5 times increased sensitivity for FHB spores and 25 times increased sensitivity for TS spores. These results suggest that RT-iPCR quantification using specific antibodies can be a very useful tool in antigenic detection of TS and FHB spores. Future experiments will focus on quantifying TS and FHB spores in real air samples using the validated RT-iPCR assays. Cross reactivity of the spores and antibodies will be verified against closely related pathogens.

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Last, but not least:

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