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| **Livestock Projects** |
| **Agri-environmental assessment of Canadian dairy farms: Towards eco-efficient management of forage crops and manure.** **Project Lead:** Martin Chantigny  Field-based activities are an integral part of dairy farm operations. While some activities such as crop selection and forage management are aimed at maximizing milk production and milk fat concentration, others such as manure management and field application are unavoidable consequences of milk production. Research under the Dairy Cluster I and elsewhere has indicated that field-based activities may significantly influence the environmental and economic sustainability of dairy farms, and may offset efforts made at the barn to reduce the environmental footprint. On the other hand, we have identified current and emerging field management practices (e.g. forage cutting management, sweet forage crops) with a strong potential to reduce the environmental footprint of dairy farming (e.g. abatement of net greenhouse gas emission; reduced irrigation) and increase economic return (e.g. reduced reliance on fertilizers and feed concentrates). However, the agronomic and environmental sustainability of these practices must be assessed in various ecozones in Canada. In addition, a comprehensive whole‐farm assessment of the environmental implications associated with these field-based management practices will be cost‐effectively achieved through a combination of field trials and computer modeling using the Integrated Farm System Model adapted to the Canadian context. The proposed, concerted multi-site field trials and modeling efforts will provide input data and coefficients from three different ecozones to Dairy Farmers of Canada and to other end users involved in life cycle assessment of the Canadian milk production. The information will also allow a refinement of Canadian methodology to estimate greenhouse gas emissions from livestock productions. |
| **Mitigation of enteric methane production from dairy cows and impact on manure emissions: Filling knowledge gaps. Project Lead** Chaouki Benchaar  Several dietary and nutritional strategies have been developed to mitigate enteric CH4 emissions from dairy cows. Among these strategies, supplementation of dairy cow diets with unprotected fat offers much potential for reducing enteric CH4 emissions. In our previous studies (Dairy Cluster 2009-2013), we have shown that increasing fat content of the diet via including dry distillers’ grains with solubles (up to 30% of dietary DM) reduced CH4 energy losses while increasing milk production and improving feed efficiency. We have also showed that the type of forage composing the diet greatly influences CH4 emissions from dairy cows. Indeed, we have shown that corn silage-based diets resulted in lower CH4 emissions than alfalfa silage-based diets. The higher starch content of corn silage compared to alfalfa silage makes the rumen environment (i.e., lower ruminal pH; shift of VFA pattern towards propionate production at the expense of acetate; inhibition of fibre degradation; lower protozoa number) less favorable to CH4 production. Collectively, these results suggest that the effectiveness of lipids at reducing CH4 emissions may vary with the basal diet, in particular the type of forage (e.g., corn silage vs. alfalfa silage) composing the diet. Little or no information exists on the interaction between fat supplementation and forage type and further investigation is required to assess the potential of fat to reduce CH4 production in dairy cows fed different sources of forage. Further, to date, most of the studies on dietary mitigation of CH4 focused only on changes in enteric emissions and very little is known on their impact on manure emissions. Thus, in the present activity, we focus on one dietary strategy with high potential for mitigating enteric CH4 emissions from Canadian dairy herds. We will investigate the effects of adding flaxseed oil in corn silage or alfalfa silage based diets on enteric CH4 emissions and performance of dairy cows (study 1). This strategy will be also evaluated for its impact on CH4 emissions from manure storage (study 2) to ensure that the possible reduction in enteric CH4 emission will not be offset by increased emissions from stored manure. |
| **Linseed oil supplementation to dairy cows fed corn silage-based diets: effects on enteric methane production, digestion, ruminal fermentation characteristics, N retention, and milk performance.**  **Project Lead** Chaouki Benchaar  Agriculture is part of the anthropological activities held responsible for climate changes by emitting greenhouse gases (GHG). Ruminants contribute substantially to agricultural GHG mainly through CH4 from enteric fermentation. Enteric production of CH4 is also a loss of productive energy for the animal, thus decreasing enteric CH4 production may improve feed efficiency and productivity. Several dietary strategies have been developed to reduce enteric CH4 production from dairy cows. Feeding rumen-unprotected fat offers much potential for decreasing enteric CH4 emissions from dairy cows. Linseed (rich in α-linolenic acid; 18:3) is one of the most effective lipid sources to reduce enteric CH4 production from ruminants.In a previous study, we showed that linseed oil (4% of dietary DM) decreased enteric CH4 production to a greater extent when added to a corn silage-based diet than to a red clover silage based-diet. In that study, supplementation of linseed oil to a red clover silage-based diet reduced enteric CH4 production (–9%) and CH4 energy losses (–11%) with no adverse effects on dry matter intake, digestion, ruminal fermentation characteristics, protozoa numbers, and milk production. The addition of linseed oil to a corn silage-based diet caused a stronger reduction in CH4 production (–26%) and CH4 energy losses (–23%) but was associated with decreases in dry matter intake, total-tract fiber digestibility, protozoa numbers, acetate:propionate ratio, and energy-corrected milk yield. These negative changes suggest that the level of 4% of linseed oil may be too high. Therefore, more work is warranted to determine the optimal concentration of linseed oil in corn silage-based diets allowing the reduction in enteric CH4 emissions without adversely affecting feed intake and animal performance. |
| **Defining the Environmental Footprint of Canadian Beef Production**  **Project Lead** Tim McAllister  1. Estimate how and why the inputs required to produce beef in Canada (e.g. land, feed, and water) have changed since 1980  2. Estimate how and why the methane and manure produced by Canada’s beef industry have changed since 1980.  3. Estimate how carbon sequestration by rangelands, biodiversity and other environmental goods and services provided by Canada’s beef industry have changed since 1980.  4. Identify potential opportunities for future improvements in the environmental footprint of Canada’s beef industry. |
| **Reactive Nitrogen and Greenhouse Gases at Cattle Feedlots​**  **Project Lead** Sean McGinn  Cattle feedlots are recognized hot spots for gas emissions in the agriculture landscape. This study examines the emissions of several gases that represent an economical loss to the producer, and a source that contributes to the environmental impact of agriculture. The study will benefit feedlot operators and local farmers by providing information on magnitude of the key emissions, and how management and adjustment for weather can offer some options for reducing these emissions. For example, the amount of ammonia that is volatilized from cattle manure may be reduced by choosing to clean pens on days having light wind speeds. There could also be an impact of crop type or surface wetness on the deposition rate of ammonia to adjacent land. Documenting the fate of emitted ammonia in the landscape will also improve the accuracy of ammonia inventories by accounting for local deposition. By monitoring several gases simultaneously, this study will also be able to make broader conclusions on the relative importance of each emission. |
| **​Invent-2020: Building a better methane emission inventory for manure management using an agri-ecosystem approach**  **Project Lead** Andrew VanderZaag  Methane emissions from manure management have come to the forefront of international agendas because it is an area where substantial mitigation can be achieved in the near-term. Canada has international commitments to reduce greenhouse gas (GHG) emissions 17% by 2020, and to reduce short-lived climate pollutants (including methane) . In Canada, the pursuit of Low Cost Domestic Reductions (LCDRs) has raised interest in emissions from manure. Farm organizations are also interested in reducing emissions to maintain competitiveness in the supply chain. Despite these interests, there is a barrier that must first be overcome: Canada’s official methane emissions are calculated and documented in the National Inventory Report, and the methodology used in this report is not responsive to differences among Canada’s ecozones, nor is it responsive to mitigation practices. In other words, if every farm in the country adopted a mitigation practice to reduce their methane emissions, the official emission reported would not change. Our project aims to overcome this barrier.  In the project we will develop a responsive methane emission model for manure management that captures relative differences across Canada’s ecozones (taking into account ecological and management factors) and validate the model using farm-scale data. Using on-farm emission measurements and complementary lab work, we will obtain emission data for specific comparisons including: climate (two ecozones: Prairies, Mixedwood Plains), livestock type (swine, dairy), and manure storage type (earthen basin, lagoon, and concrete tank). In addition to being ecozone-specific, the model will account for mitigation practices including: frequent manure removal, solid-liquid separation, methane oxidation, and anaerobic digestion. |
| **​Methane emissions from beef cattle bred for low residual feed intake**  **Project Lead** Vern Baron  Globally, annual man-made greenhouse gases (GHG) emissions were about 50 Gt carbon dioxide equivalents (CO2e)/year in 2005, with agriculture accounting for 9-11% or 4.5-5.5 Gt CO2e/yr (Tubiello et al. 2013; Smith et al. 2007). These agriculture emissions grew at an annual rate of 0.95% from 1961 to 2010, such that total GHG emissions from agriculture in 2010 were about 5.4-5.8 Gt CO2e/year (Tubiello et al. 2013). Enteric methane emissions produced by microbes fermenting feed in the animal’s reticulo-rumen, manure left on pasture, manure management and manure applied to soil accounts for 71% of total agricultural emissions, making the ruminant animal a major contributor to global agricultural GHG emissions. |
| **EVALUATION OF GREENHOUSE GAS EMISSIONS FROM GRAZING RUMINANTS ON GRASSLANDS ON DIFFERENT DIETARY TREATMENT**  ​  **Project Lead** Alan Iwaasa  Collaborative research study between AAFC-SPARC and Qinghai Academy of Animal and Veterinary Science was first initiated in 2012 and will continue till April 2018. In the collaboration study, methane emissions will be measured from grazing ruminants (e.g., yaks etc.) under different dietary treatments (control, energy and protein supplement etc.) and management feeding practices (i.e., time of grazing, rotation, etc.) to determine potential GHG mitigation opportunities and livestock performance benefits. The study will use individual animals or paddocks as the experiment unit and the study will be replicated over treatments. In the course of this research collaboration exchange of AAFC researchers and Qinghai University researchers between the two research institutions will occur. |
| **Evaluation of Purple Prairie Clover as a Novel Forage for the Sustainable Growth of Cattle Industry**  **Project Lead** Yuxi Wang  ​Forage is an important feed for ruminants and some condensed tannin (CT)-containing forage can benefit ruminant health and growth but only few CT-containing forages are available in Alberta. There is a great need to develop new forages to increase the availability and diversity for the sustainable growth of cattle industry. Purple prairie clover (PPC) is a native legume, contains CT that not only improve protein utilization but also reduce E coli O157:H7 fecal shedding and hence it has great potential as a novel forage. However, there is little information on its capacity of establishment in cultivated land and nutritional characteristics. This proof-of concept project will determine some basic agronomic characteristics, yield and nutrient compositions. Information obtained will contribute to our existing knowledge in understanding this potential forage. Successful completion of the project will benefit forage and beef industries by offering the option of producing and using a novel and high nutritive forage and offering potential approaches to mitigating greenhouse gases emissions from the perspective of an improvement in N utilization and a reduction in enteric methane production.​ |
| **Assessment of the impact of feeding management practices on methane emissions from enteric fermentation and manure storage of dairy cows: filling knowledge gaps.**  **Project Lead** Chaouki Benchaar  Methane is a potent greenhouse gas (GHG) produced primarily in the rumen during microbial feed digestion (i.e., enteric fermentation) and to a lesser extent from manure storage. Enteric CH4 also represents a significant loss in productive energy to the dairy cow. The impact of several nutritional strategies (e.g., feeding high-grain diets, supplementation with ionophores or fat) on enteric CH4 emissions from ruminants is well documented. However, nutrition encompasses not only diet manipulation (quantitatively and qualitatively) but also feeding management practices that can affect consumption and excretion of nutrients and thus, animal performance (e.g., milk production). No information is currently available on the effect of feeding management practices on CH4 emissions from dairy operations. For instance, information on the impact of feeding frequency and feeding total mixed rations (TMR) vs. feeding forages and concentrates separately on CH4 emissions from enteric fermentation and manure storage is almost inexistent. Under conventional dairy farm practices feed is delivered to cows twice per day. However, many producers choose to feed their cows only once per day to reduce labor costs. On the other hand, the majority of lactating dairy cows are fed TMR offered ad libitum. However, a significant number of dairy producers still feed forages and concentrates separately. Thus, there is a need to investigate the effects of such feeding management practices not only on CH4 emissions from enteric fermentation and manure storage (environmental impact) but also on feed efficiency and productivity of dairy production (economic impact). The objective of this proposal is to assess the impact of feeding frequency (1. vs. 2 and 4 times/day) and feeding method (TMR vs. forages and concentrates separately) on CH4 emissions (enteric fermentation and manure storage), feed intake, digestion (ruminal and total-tract), ruminal fermentation characteristics (including protozoa population), N balance and milk performance (production and composition). This proposal provides an opportunity to fill knowledge gaps of the impact of feeding management practices on GHG emissions by dairy production. |
| **Novel vs. traditional manure/compost to conserve soil resources and improve soil health**  **Project Lead** Xiying Hao  Sustainable beef cattle production is of global importance with annual meat production expected to more than double levels by 2050. The world’s 1.4 billion cattle produce 9.4% (4.6 Gt CO2 equivalent yr–1) of greenhouse gas (GHG) emission, thus offering considerable potential for mitigation of climate change. Reducing ruminal CH4 emission by adding 3-nitrooxypropanol (NOP) – a CH4 emission inhibitor - to beef cattle diets can reduce CH4 emissions by 59%. What happens to NOP after excretion and how NOP affects beef cattle manure decomposition, N and P dynamics, GHG emissions, and microbial diversity/function in cattle manure during storage, composting and after land application is unknown.In order to develop manure management BMPs and in anticipation of NOP becoming part of Canadian cattle diets, we propose to investigate (Obj. 1) the impact of NOP in cattle diets throughout the manure lifecycle and (Obj. 2) soil health in response to novel organic amendment applications. Specifically, for Obj. (1) we will conduct five experiments to investigate the physico-chemical and biological processes pertinent to GHG emissions and N and P nutrient dynamics during NOP vs. non NOP manure storage (Obj.1.1), composting (Obj. 1.2), biogas production (Obj. 1.3) and manure/compost land applications for forage feed production (Obj. 1.4). We will measure CH4, CO2 and N2O flux, N, P and mineral (K, Ca, Mg) availability, and the microbial community during n the manure lifecycle. For Obj. (2), we will conduct four lab and field experiments to investigate how recent and long-term cattle manure applications affect soil health by studying the effect of NOP manure/compost and other novel amendments using soil microcosms (Obj 2.1), validate microcosm studies with field sites with recent NOP and non NOP manure/compost application (Obj. 2.2) and study field sites with continued and discontinued cattle manure applications since 1973 (Obj. 2.3) and define relationships between C-input, nutrient cycling, enzyme activity, and C-sequestration for soils according to organic amendment type and application history (Obj. 2.4).We also propose (Obj 3) to evaluate processes that drive losses and transformation of N and P in soil and groundwater under long–term (43+ years) manure application. We will enhance monitoring and establish the spatial distribution of impacts over an experimental site (Obj 3.1). Subsequently, we will focus on field research and simulation modelling of groundwater recharge and N and P leaching under rain and irrigation conditions in Southern Alberta (Obj. 3.2). Furthermore, we will investigate the feasibility of complete denitrification as a means of mitigating N2O emissions to air, under both natural attenuation and bio-stimulation. Indigenous denitrifiers will be tested to determine their potential as passive low-cost treatments. (Obj. 3.2).Advancement of BMPs for beef cattle feedlot production in southern Alberta requires novel knowledge related to N and P cycling, GHG emissions and C sequestration potential in NOP-manure and new amendments while meeting the environmental and economic objectives of sustainable production. New BMPs will maintain or improve soil and environmental health and optimize synchrony between nutrient release and crop demand while clearly defining the C footprint and environmental effects of NOP-manure. This work will quantify the sustainability of beef cattle manure from NOP supplemented beef cattle diets, and lay the foundation for strategies to reduce beef cattle feedlot GHG emissions, while developing applicable soil health assessment tools for a diverse range of agroecosystems in Canada. |
| **Study of the efficiency of swine manure management practices and treatments to decrease the environmental impact of the swine production system**  ​  **Project Lead** Guylaine Talbot  Livestock manure represents an important source of biological contaminants and its management has to be improved. Stored manure is a reservoir of bacterial and viral pathogens and antibiotic resistant bacteria and genes that could compromise animal and public health if manure comes in contact with water or raw foods after land application as a fertilizer. In addition, specific microbial communities in stored manure are directly responsible for greenhouse gas (GHG) emission and therefore contribute to climate change. Confined livestock production systems that store manure offer the opportunity to treat manure prior to recycling into crop production and to mitigate methane emission. The research project aims at improving the environmental performance and the sustainability of the Canadian swine production industry. The main project outcomes will identify manure treatments effective at reducing the environmental impact of swine production while conserving fertilizer value. The project will contribute to a better understanding of how soil microbial communities and physicochemical properties are affected by treated manures used as a fertilizer.This project will compare the environmental impact of raw swine manure with that of treated manures. Based on our previous work, manure treatments would be: acidification, solid/liquid separation technologies, and concentration by membrane filtration. The environmental impact will be assessed by the determination of: 1) the persistence of viral and bacterial pathogens, antibiotic resistant bacteria and methanogenic communities; 2) the methane emission rate during manure storage; 3) the fertilizer value (plant growth bio-assays) and gaseous N emissions of manure-amended soil microcosms; and 4) the soil quality attributes (physicochemical properties, active microbial communities) following manure application.This proposal will provide a unique opportunity to obtain science-based knowledge that can be used to adopt better manure management practices at the farm in order to reduce the environmental risk associated with pathogens and GHG emissions, also assessing the impact of treatments on the fertilizer value of manures. It will support the Environmental Farm Plan program administered by provinces to mitigate environmental risks on farms.The outcomes of the project will also be made available for a better quantification of GHG emission intensity of pork products to support GHG mitigation policies (support to the Global Research Alliance (GRA) framework).The project will therefore contribute to improve the resilience and sustainability of the swine production sector. In a global context of increasing demand for animal products while ensuring protection of environmental, animal and human health, outcomes will be used to promote better manure management practices at the farm. The science outcomes will contribute to maintain export market access by increasing competitiveness and sustainability of the Canadian swine industry and provide potential best manure management practices for the entire livestock sector. In brief, the project will contribute to reduce the environmental impact on air/ water/soil quality of the swine agri-sector through the determination of manure treatments that reduce the persistence of major and emerging bacterial and viral pathogens in manure storage tanks, including antibiotic resistant bacteria and genes, and through the identification and monitoring of active microbes and factors among the manure properties that are responsible for GHG emissions and plant growth. |
| **Management strategies to improve rangeland soil health and productivity**  **Project Lead** Xiying Hao  Conservation of soil moisture will allow the ranching industry to adapt to the increasingly severe weather events that have resulted from climate change. Healthy rangeland soils have a porous structure which allows precipitation to infiltrate readily and provides a large storage capacity. Abundant plant litter conserves soil moisture and prevents erosion. Unhealthy rangeland soils are often compacted, which reduces water infiltration and gas exchange, impairs root growth and reduces soil microbial activity.  Two experiments will take advantage of long-term grazing trials at Stavely, AB to document the effects of heavy grazing on rangeland soil health. Some effects of grazing on soil chemical and physical properties have been reported, but little is known of the effects on soil microbial activity and diversity. The long-term effects of heavy grazing on soil health will be determined with and without experimentally imposed drought. We will take advantage of an existing 15 year study of recovery of plant communities from heavy stocking rates to determine the resilience of soil health after grazing is removed.  BMP’s to improve range soil health will also be developed. Switching from spring to fall grazing can ameliorate degraded rangeland plant communities without reducing stocking rates. There are few studies of the effects of season of grazing on soil properties, but one published study on BC rangeland indicated that fall grazing increased root growth and improve soil physical and chemical properties. Leaving plant litter on the soil surface has been shown to increase forage production by up to 20% on mixed prairie. The mulch provided by litter reduces evaporation and moderates soil temperature. Decomposition of plant litter and roots can sequester C into soil organic matter. Because the benefits of plant litter can vary with plant community type, a multi-site trial (involving four rangeland plant community types) is proposed to look at the interacting potential of season of grazing and plant litter to improve rangeland soil health. Combinations of clipping and litter treatments will be applied with and without added drought.  Some of the response variables to be measured include: soil physical: aggregate stability, bulk density, compaction, volumetric moisture content, surface temperatures, thermal diffusivity, water infiltration rates; soil chemical: CEC, pH, light fraction C, available N, P, K, total C and N; soil biology: microbial biomass (soil microbe C), microbial enzyme activities (involving C, N, P, and S cycling) microbial diversity (next generation DNA sequencing) and plant responses: root productivity, aerial biomass, plant community composition, and N uptake.  This study will apply the concepts of soil health to rangeland and determine which soil characteristics are most affected by cattle grazing. Knowledge the role of microbes in maintaining and restoring rangeland soil health will be greatly expanded. The resilience of unhealthy rangeland soil will be determined. BMP’s will be developed to improve rangeland soil health. These results will be demonstrated to producers in field days and seminars. |