

Identifying and addressing knowledge gaps and challenges involving greenhouse gases in agriculture systems under climate change

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Today's food and agriculture system faces ever-widening challenges as it reacts to market trends, new technologies and growing regulatory pressures. Additional challenges are the management decisions for crops, water, pests, and diseases that are likely affected by increasing climate variability.

Canada committed to reduce greenhouse gas (GHG) emissions six percent below 1990 levels by ratifying the Kyoto Protocol in December 2002. In their Options Paper, the Agriculture and Agri-Food Table of the National Climate Change Process identified current knowledge gaps as one of the significant impediments for developing an action plan in response to Kyoto. There have been several programs undertaken to identify and address these research gaps. These include the Climate Change Funding Initiative in Agriculture (CCFIA), the Biological GHG Sources and Sinks Program (BGSS), and the Alberta GHG Science Plan.

In February 2000, the federal Minister of Agriculture and Agri-Food Canada announced \$4 million in funding over 4 years from the Canadian Adaptation and Rural Development II (CARD II) program for a CCFIA. The Canadian Agri-Food Research Council (CARC) was responsible for delivering the CCFIA with the following four goals:

1. Increase Canadian human resource research capacity and expertise in climate change issues in agriculture.
2. Research on knowledge gaps in agricultural GHG emissions.
3. Development of industry best practices and technology to reduce agricultural GHG emissions and increase carbon sequestration potential of agricultural soils.
4. Enhance awareness and improve communication on climate change.

Fifteen research projects were funded, involving a total of 45 graduate students plus supported two research chairs. The research projects funded involved a wide range of institutions and sectors of Canadian agriculture and were specifically asked to address the knowledge gaps identified in the Options Paper. These included studies examining

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GHG emissions from swine, dairy and cattle production, nitrogen management practices to reduce GHG emissions, and the influence of landscape on GHG emissions and carbon sequestration. Final reports from these projects can be found on the CARC website (www.carc-crac.ca).

Agriculture and Agri-Food Canada is leading the BGSS program by supporting collaborative field, laboratory and modeling studies in agriculture using teams of government and university scientists. The critical need for future scientists to be trained in global climate change research is assisted through the program's financial support of graduate students. The BGSS program supports the environmental objectives of the Agriculture Policy Framework Agreement signed by the federal, provincial and territorial governments in 2001.

The goals of the BGSS program are to:

1. Improve knowledge on biological GHG sources and sinks for increasing and assessing carbon stocks in the agricultural sector. Research focuses on key biochemical, physical and physico-chemical factors influencing soil carbon oxidation and stabilization, and processes involved in nitrous oxide emissions from soils;
2. Build scientific capacity through training of new scientists.

The focus of research for agriculture is in four areas:

- Knowledge based processes for biological GHG sources and sinks;
- Measurement and spatial variability of GHG sources and sinks;
- Modelling of biological GHG sources and sinks;
- Impact of legume crops on carbon sequestration and nitrous oxide emissions.

Initiated in 2002, the program is funding twelve research projects across Canada. All are collaborative projects where graduate students are jointly supervised by teams of academic and Agriculture and Agri-Food Canada research scientists. Details of individual projects can be found on the CARC website (www.carc-crac.ca).

In the Alberta GHG Science Plan, over 2600 scientific papers and publications were examined, organized into a bibliographic database and then summarized into a report titled "*Development of a Farm-Level Greenhouse Gas Assessment: Identification of Knowledge Gaps and Development of a Science Plan*". Knowledge gaps were prioritized at a workshop in 2003 for five different management areas: soil and crop management, livestock management, manure management, land use and energy, and whole farm integration. The goal of this process was for funding agencies to fund research in the areas where gaps were identified.

However, funding agencies requested more detail and suggested a strategic road map for GHG research be developed. In June 2004, university researchers, provincial and federal employees, agricultural producers and funding agencies prioritized management practices for their potential to reduce GHG emissions. The list of management practices analyzed was compiled from lists produced by the CCFIA, Alberta Agriculture GHG Technical Team and Alberta's Agriculture Policy Framework team. The result is a list of potential management practices (Table 1) that producers could employ to reduce GHG emissions in five different areas: livestock; manure; annual soil and crops; perennial soil and crops; land use and energy.

Table 1: Potential management practices that will reduce the most GHG emissions

| Management Practice | GHG Reduced | | |
|--|-----------------|-----------------|------------------|
| | CO ₂ | CH ₄ | N ₂ O |
| LIVESTOCK PRACTICES | | | |
| Analyze feed and formulate rations to feed livestock a balanced diet | | ✓ | ✓ |
| Genetically select for feed efficiency | | ✓ | ✓ |
| Include edible oils in cow winter/grazing diet | | ✓ | |
| MANURE PRACTICES | | | |
| Process liquid or solid manure anaerobically (biodigestors) | | ✓ | ✓ |
| Compost manure | | ✓ | ✓ |
| Use low disturbance injection or incorporation of manure within 24 hours | | ✓ | |
| Cover liquid and slurry manure storage systems with straw or synthetic cover | | ✓ | |
| ANNUAL CROP AND SOIL PRACTICES | | | |
| Soil test periodically before applying fertilizer to ensure applied N meets crop needs | | | ✓ |
| Reduce fall nitrogen application by applying nutrients in the spring | | | ✓ |
| Use reduce tillage or no-till seeding of crop | ✓ | | |
| Include perennial crops in rotations | ✓ | | |
| Use chemfallow instead of summerfallow | ✓ | | |
| Reduce fallow in rotations | ✓ | | |
| PERENNIAL CROP AND SOIL PRACTICES | | | |
| Manage forage utilization through timing and frequency of grazing | ✓ | | |

| | | | |
|---|---|--|---|
| using practices such as controlled rotational grazing on permanent and cropland pasture and controlled grazing on extensively managed native and naturalized pastures and ranges | | | |
| Rejuvenate pasture stands using direct seeding, chemical control, seed selection and fertilization | ✓ | | |
| Prevent overgrazing by using proper stocking rates as dictated by species, climate and site-specific soil conditions | ✓ | | |
| Distribute animal manure on pastures uniformly by moving water, shelter, mineral and salt supplements and temporary fencing periodically and by managing animal density on pastures | | | ✓ |
| LAND USE AND ENERGY PRACTICES | | | |
| Convert marginal cropland to pasture, grassland, trees or wetlands | ✓ | | ✓ |
| Energy and water efficient retrofits and conservation | ✓ | | |
| Reduce fossil fuel energy consumption by using shelterbelts, solar heating, wind and biogas production | ✓ | | |
| Preserve and enhance existing wetlands | ✓ | | ✓ |

The Expert Committee on Greenhouse Gases and Carbon Sequestration, through its involvement in the above programs as well as other national and international initiatives maintains a list of research gaps. A detailed listing of these research needs is included as part of their annual report to CARC and is available through CARC. The Expert Committee identified needs to:

- Examine **crosscutting issues** related to economic life-cycle analysis of practice adoption to reduce GHG emissions. This includes the integration of carbon, nitrogen and phosphorus cycles in nutrient management and GHG mitigation.
- Focus and support research examining the **adaptation** of agricultural systems to climate change. This should include the effects of drought, changing pest populations, carbon dioxide fertilization on crop production and socio-economic impacts of climate change. Canadian Climate Impacts and Adaptation Research Network (C-CIARN) for Agriculture has been effective in assessing research needs in this area (www.c-ciarn.uoguelph.ca).
- Develop and disseminate a national system of **measurement, verification and validation** of GHG emissions. This includes improved measurement techniques, standardized protocols and monitoring of GHG sources and sinks in Canadian agriculture. This will allow for better integration of fundamental ecological models into our understanding of biological processes that emit GHG.
- **Continued research** into mitigation strategies in the areas of animal production, soils and crops, manure management and land use and energy products.