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Effects of Agricultural Water Management Systems on Greenhouse Gas Emissions in Eastern Canada

Agriculture and Agri-Food Canada

Agriculture et Agroalimentaire Canada

Goals:

- *Collaborate with agricultural producers and government stakeholders across a range of disciplines to quantify GHG emissions in Eastern Canada*

- *Develop knowledge on the interactions between various agricultural water management practices and GHG emissions, and enhance production efficiencies*

Objectives:

- **Conduct scientific research:** measure, quantify, and validate cause and effect relationships between irrigation, water table management, drainage and agronomic practices on GHG (N_20, CH_4, $C0_2$) emissions and C sequestration

- **Investigate cost-effectiveness:** benefits of new technologies for mitigating GHG emissions and improving water use efficiency under different water management systems

- **Economic analysis:** investigate benefits and costs of adopting selected BMPs at the farm level using whole farm analysis

- **Develop and implement:** cost-effective technologies and BMPs to help Canadian crop producers mitigate GHGs, improve water use efficiency, reduce agricultural inputs, and improve economic returns

Objectives:

- **Develop and test regional models:** compare and evaluate the efficiency and cost-effectiveness of the different technologies and BMPs developed and provide policy decision-support tools to encourage the implementation of profitable and sustainable GHG mitigation practices

- **Network:** strengthen local, national and international networking channels to enhance partnerships, develop new relationships with agricultural producers and stakeholders, and to promote information sharing and dissemination of the technologies and BMPs developed

- **Build Canadian professional capacity:** in GHG mitigation strategies for water use efficiency, and enhance Canadian contributions to the GRA.

Research team:

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Collaborators

Organization	Expected role and contributions	Outputs
Ontario Fruit and Vegetable Growers Association	Provide guidance on GHG mitigation technologies; disseminate information; hosting field days.	Host field demonstration days in Ontario; deliver technical newsletters.
Ontario Ministry of Agriculture, Food and Rural Affairs	Provide technical advice on irrigation and drainage technologies and crop management; support the development of extension materials and events.	Host local workshops and/or field days in Ontario and deliver extension materials.
International Commission on Irrigation and Drainage (ICID)	Provide an international network to share GHG mitigation technologies and BMPs with GRA members.	Host workshops on GHG mitigation technologies as part of its regular annual meetings; deliver extension materials; develop parallel research projects in GRA countries.
Canadian National Committee for Irrigation and Drainage (CANCID)	Provide a national network to share GHG mitigation technologies and BMPs.	Deliver technical information through its newsletters, website and national meetings.
Association des jardiniers maraichers du Québec	Provide links to Quebec agricultural producers to extend the transfer of research information and assist with the development of extension materials.	Host demonstration days, workshops and deliver extension materials in Quebec.

Collaborators (cont'd)

Organization	Expected role and contributions	Outputs
Ministère d'agriculture, pêcheries et alimentation de Québec	Provide links to local producers to extend the technical transfer; provide expert input; assist with the development of extension materials.	Host local workshop that includes GHG mitigation technologies for producers in Quebec. Deliver extension materials through the MAPAQ website.
Institut de recherche et de développement en agroenvironnement (IRDA)	Support the information transfer activities, with the goal of contributing to the sustainable development of agriculture.	Help train a new generation of agricultural professionals with knowledge of GHG mitigation technologies.
Centre de recherche en horticulture, Université Laval	Provide information and access to research sites in Quebec.	Deliver technical expertise on water management for sustainable horticultural production.
Agriculture and Agri-Food Canada **Guelph, Ontario**	Provide technical support; dissemination of extension materials in Ontario.	Disseminate extension materials.
Agriculture and Agri-Food Canada **Outlook, Saskatchewan**	Transfer knowledge from Eastern Canada to Western Canada; assist with the dissemination of extension materials for national use.	Disseminate extension materials.

Collaborators (cont'd)

Organization	Expected role and contributions	Outputs
Eastern Canada Soil and Water Conservation Centre	Provide technical support and assist with the development of extension materials in the Maritime provinces.	Deliver extension materials in the Maritimes through their website and publications; host workshops in the Maritime provinces.
Nova Scotia Federation of Agriculture	Provide guidance on GHG mitigation technologies; disseminate information; hosting field days.	Host field demonstration days in Nova Scotia; deliver technical newsletters.
Canadian Water Resources Association	Facilitate discussion among water users and water resource professionals across Canada.	Deliver results of the research to water users and water resource professionals across Canada through its website, publications and technical meetings.

Research sites and treatments

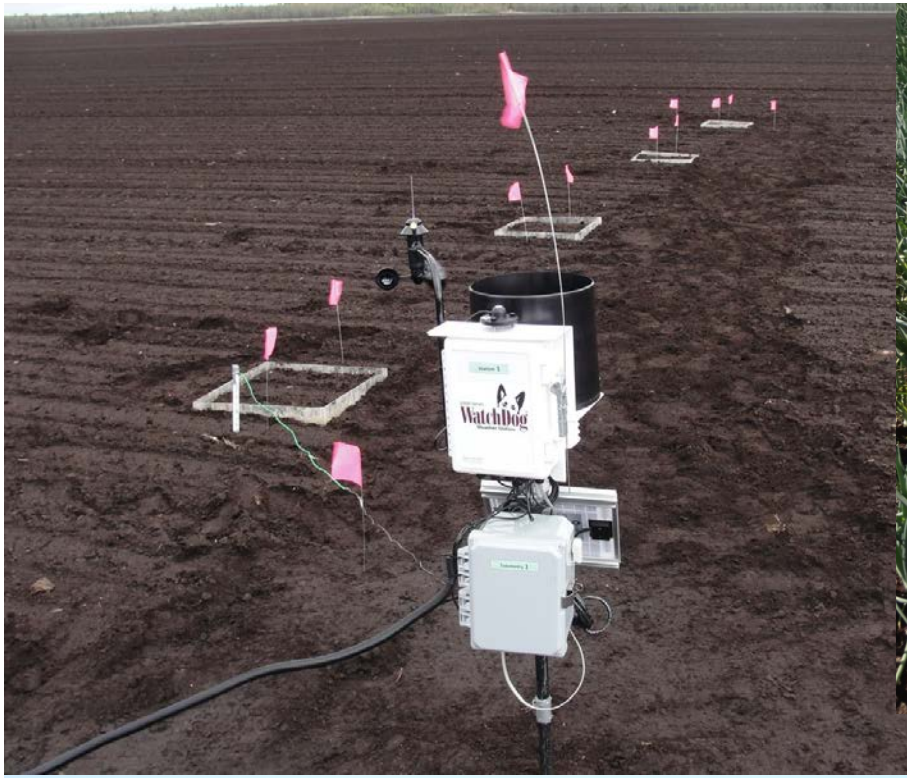
Research Site	Treatments
St Emmanuel (QC)	▪ Free drainage, Controlled drainage ▪ Corn
Sherrington (QC)	▪ Surface irrigation, No irrigation ▪ Mineral soil, Intermediate soil ▪ Onion
St-Louis-de-Blanford (QC)	▪ Well drained field, Flooded field ▪ Natural bog ▪ Cranberry
Leamington (ON)	▪ Tile drainage ▪ Surface drip, Buried drip irrigation ▪ Tomato
Harrow (ON)	▪ Water table management ▪ Variable fertilizer/manure application ▪ Corn/soya
Truro (NS)	▪ Free drainage, controlled drainage, irrigation ▪ Pasture

Field data collection

Soil Physical Analysis
Texture
Bulk density
Hydraulic conductivity
Porosity
Soil Chemical Analysis
Organic matter
pH
Total C
Total N
KCl-extractable N (NH_4 plus NO_3)
Mehlich-3 extractable P
K
Al
Greenhouse Gas Sampling
N_2O, CH_4 and CO_2 (using the closed chamber technique)
Dissolved N_2O (in tile drainage and./or surface water at selected sampling dates)

Water Analysis
Dissolved organic C
NH_4
NO_3
Dissolved organic N
Particulate N
Ortho-P
Dissolved organic P
Particulate P
Agronomic Data
Crop height
Crop yield at harvest
Grain and stover/straw biomass (by weighing) and determine N content of grain and stover/straw

Field Survey and Mapping
Field elevation maps
Apparent soil electrical conductivity
Soil optical reflectance (in some cases)
Mid-season crop canopy reflectance (chlorophyll index)
Crop height
Satellite imagery
Gamma-radiometry
Hyperspectral soil profiling with electrical conductivity and mechanical impedance
Temporal monitoring of water and temperature in strategic locations


WatchDog

McGill Water Management Research Facility

St. Emmanuel, Qc

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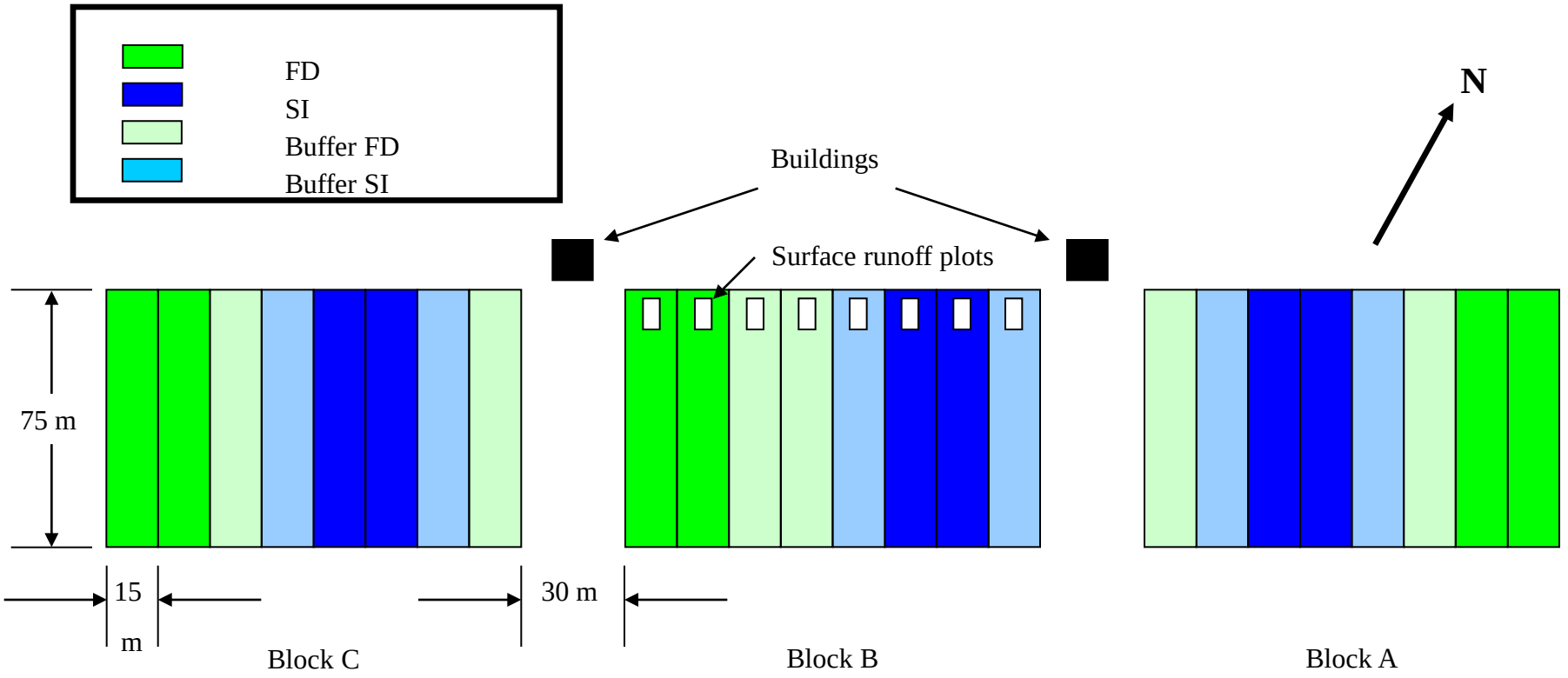

McGill Water Management Research Facility

St. Emmanuel, Qc

Field Layout

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Gas Sampling – Cranberry field

Source: A. Grant (19 Nov 2011)

Deliverables

- New water management practices to mitigate GHG emissions that agricultural producers can adopt to improve sustainability and profitability
- Outreach and technology transfer plan to enable deliverables to be incorporated directly into farmers' practices
- GHG emission model to inform decision makers and encourage the implementation of profitable and sustainable GHG mitigation practices
- Workshops and roundtable discussions to validate experimental approaches and mitigation strategies
- Presentations at local, national and international conferences, stakeholder meetings, and research symposiums presenting technologies developed to Canadian producers, GRA member countries, and the international community

Deliverables (cont'd)

- Development and fostering existing relationships between agricultural producers and stakeholders and strengthen local, national and international networking channels
- Information that can be shared locally, nationally, and internationally by publishing BMP manuals, brochures, information booklets and pamphlets, and e-newsletters
- A new generation of professionals, strengthen Canada's leadership capacity in agricultural GHG mitigation strategies, and enhance Canadian contributions to the GRA
- Contributions to the scientific community by publishing science-based results from GHG mitigation research and water use efficiency in scientific journals, technical bulletins, and farm trade magazines
- A comprehensive final project report to summarize project findings

Project timeline to November 2012

September– November 30th 2011 (First season for field experiments)

- Confirm the research sites in Quebec, Ontario and Nova Scotia
- Enter into farmer and stakeholder agreements
- Initial site assessments and characterizations
- Collect Fall data on soils, and GHG emissions data
- Recruit graduate students and summer students

December 1st 2011 – March 31st 2012

- Analyze preliminary field data collected
- Refine methodology and experimental techniques
- Collect all water use, drainage, irrigation, soils, crops and GHG emissions data
- Collect farm economics and budget data

April 1st 2012 – November 30th 2012

- Meet with agricultural producers to review methodology
- Complete site assessments and characterizations
- Set up field sites
- Collect data on soils, water use, and GHG emissions data
- Implement and test first set of BMPs in conjunction with agricultural producers

2013 Work Plan

December 2012 – March 2013

- Analyze data for first field season
- Interpret results and modify BMPs based on lessons learned
- Hold consultations to review project implementation and results
- Begin whole farm budget analyses and cost benefit analyses
- Refine methodology and experimental techniques based on field findings
- Order all necessary field supplies and equipment
- Hire students for the second summer research season

April – October 2013

- Set up field sites for second year of sampling
- Implement and test refined BMPs in conjunction with agricultural producers
- Collect all water use, drainage, irrigation, soils, crops and GHG emissions data
- Collect farm economics and budget data
- Train agricultural producers in BMPs and improved soil, water and cropping systems
- Host a grower field day at one of the research sites

2013 Work Plan (cont'd)

November – December 2013

- Analyze second year of field data
- Interpret results and modify BMPs based on lessons learned
- Hold a workshop for producers and producer organizations
- Undertake whole farm budget analyses and cost benefit analyses

December 2013 – March 2014

- Begin developing computer models to simulate GHG emissions under different management scenarios
- Refine methodology and experimental techniques based on field findings
- Present results at producer organization meetings
- Order all necessary field supplies and equipment
- Hire students for the third summer research season

THANK YOU

St. Emmanuel, Quebec

Characteristics	Content
Crop production	Corn
Elevation	Flat, about 52m above MSL
Soil	Very fine Soulange loam Deposit method: fluviatile and marine Size: coarse-loamy
Goal	Assess the impacts of subirrigation, surface drainage and subsurface drainage on GHG emissions
Water management system	Divided into 24 plots (15m x 75m), separated by vertical plastic sheets. 24 drains discharge water separately into two buildings, allowing drainage measurement from each plot

Sherrington, Quebec

Characteristics	Content
Crop production	Onion
Elevation	52 – 60 m above MSL
Soil (organic)	Poor, medium, highly decomposed black soil
Goal	Determine the influence of organic soils on GHG emissions based on different agronomic practices and water management strategies
Water management system	▪ Crops are sprinkler irrigated ▪ Drainage system consists of 100 mm diameter corrugated plastic tubing spaced 18 m apart, with lengths ranging from 122 to 420m ▪ Collectors (150mm diameter) with outlet emerging at a depth of about 16m into trenches ▪ Water table controlled with a chamber located between the end of the collector and the outlet

St-Louis-de-Blandford, Quebec

Characteristics	Content
Crop production	Cranberry
Elevation	100 – 127 m above MSL
Soil	Sainte-Sophie loamy sand Saint-Samuel organic
Goal	Develop better understanding of how soil and water management interactions in cranberry production can influence crop yield, fruit quality, and GHG emissions.
Water management system	▪ Water-intensive production. Irrigation requirements are met with sprinklers during growing season ▪ At harvest, fields are flooded for several days, the fruit is released from the vine and is suspended in water ▪ Fruits are then skimmed from the water surface

Leamington, Ontario

Characteristics	Content
Crop production	Tomato
Elevation	188 - 190 m above MSL
Soil	Berrien Sandy Loam: Brown sandy loam over yellow and then mottled sand with clay at about 3 to 6 feet; stone-free; smooth to undulating. Fair to poor drainage. Moderately acid.
Goal	Investigate effects of both buried and surface drip irrigation on GHG emissions.
Water management system	Processing tomatoes are grown with both buried and surface drip irrigation. In the case of the buried drip, the irrigation tape is located approximately 20 cm below the soil surface.

Harrow, Ontario

Characteristics	Content
Crop production	Corn / Soya rotation
Elevation	185 - 186 m above MSL
Soil	Brookston Clay; Dark clay over mottled clay then blue-grey compact gritty clay; few stones. Almost level with poor natural drainage. Slightly acid to slightly alkaline(Soil Survey Report No. 11, 1947).
Goal	Assess primarily GHG emissions from surface runoff and subsurface drainage, and fertilizer use
Water management system	Two water management (free drainage, controlled drainage-sub irrigation) and four phosphorous sources (inorganic fertilizer control, liquid cattle manure, solid cattle manure, and a P-draw down).

Truro, Nova Scotia

Characteristics	Content
Crop production	Pasture field
Elevation	18 - 44m above MSL
Soil	Truro Soil: 60 – 80 cm of loamy sand to sandy loam over very friable to firm, red, glacio-fluvial fine sands and loamy sands. Rapidly to well drained soils.
Goal	Assess the impacts of subirrigation and subsurface drainage, and controlled drainage on GHG emissions.
Water management system	▪ Plots can be operated as drained, controlled or irrigated; excess water recovered in a pond. ▪ Control chambers can be set to no-restriction, controlled drainage or sub-irrigation. ▪ Drainage lines are connected to a pipe at the bottom of each plot; pipes run to a sampling hut.