The Carbon Footprint of Canadian Crops

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Topics

• What is a Carbon Footprint?
• System Boundaries
• Regional Approach
• Crops Studied
• Data Collection
• Some Results
• Closing Thoughts
A carbon footprint is usually defined as the total sets of greenhouse gas emissions and removals (expressed as CO$_2$ equivalent) caused by an organization, event, product or individual.
Carbon Footprint Standards

• There are three main Product Carbon Footprint standards that are applied worldwide: PAS 2050, GHG Protocol and ISO 14067.
  – PAS 2050 has been developed by the British Standards Institution (BSI) and came into effect in October 2008.
  – The GHG Protocol product standard has been developed by the World Resources Institute (WRI)/World Business Council Sustainable Development (WBCSD) and was launched in October 2011.
  – ISO 14067 was released by the International Standards Organization as a Technical Specification in 2013.
Carbon Footprint Standards

• All three systems provide requirements and guidelines on the decisions to be made when conducting a carbon footprint study. Decisions involve LCA issues, like goal and scope definition, data collection strategies, and reporting. Moreover, these systems provide requirements on specific issues relevant for carbon footprints, including land-use change, carbon uptake, biogenic carbon emissions, soil carbon change, and green electricity.
System Boundaries

• What is included and what is not?
• This is the area of the primary difference between the three standards.
• This work follows the ISO 14067 Technical Specification. It includes changes in soil carbon and uses the methodology used in Canada’s National Inventory Report as recommended in the standard. This work does not include any emissions associated with the capital infrastructure.
For this work the system boundary for all product systems includes:

- The seeds, fertilizers and pesticides acquired and applied to the soil and plants, including the GHG emissions associated with the production, transportation and application of these crop inputs.

- The fuel and energy consumed in the field work (tillage, seeding, fertilizing, spraying, and harvesting activities) and the transportation of the product from the field to the on farm storage bin. This includes the emissions associated with the production and use of the energy products.

- The emissions from the decomposition of the applied fertilizer products and the crop residues that are left on the field after harvesting the grains and oilseeds.

- Changes in soil carbon resulting from changes in land management. This is consistent with ISO 14067 and the GHG protocol.
System Boundaries

The activities that are **not** included in the system boundary include:

- The manufacture, maintenance and decommissioning of capital equipment. This is consistent with PAS 2050 and the GHG Protocol product standard.
- The emissions associated with ancillary operations such as lighting and heating of indoor work areas.
- The disposal of process wastes and products. These are very minor quantities in most instances and would typically only include packaging wastes.
- On-farm production of renewable energy including, for example, solar, wind, biogas or biomass combustion.
- Transportation and processing of the products beyond the farm gate. This would be included in the use phase of the products.
Regional Approach

• Previous work, such as the carbon footprinting that has been done for western Canadian canola and barley, has shown that there can be significant differences in the GHG emissions for crop production across the Prairies Provinces.

• This variation can be due to production practices, soil conditions, and climate, it is appropriate to look at the GHG emissions and removals on a regional basis.

• One appropriate means of regionalizing the calculations is to use the reconciliation unit (RU) approach, which has been developed by AAFC and Environment Canada and is described below.
RUs
Carbon footprints are calculated for the ten major crops in Canada.

A major crop is considered to be a grain or oilseed with more than 500,000 tonnes of annual production.

An RU was considered for calculation if it had more than 10,000 ha of cropland.
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Data Collection

• A variety of sources were used.
  – Statistics Canada.
    • Yield and production.
    • Fertilizer type by province.
  – AAFC
    • $\text{N}_2\text{O}$ emission factors and soil carbon changes by RU
  – Crop insurance management programs
  – Cheminfo fertilizer manufacturing carbon footprint study
  – Other Canadian government sources, e.g. pesticide sales
  – Some USDA ARMs survey data
  – Private surveys
  – Peer reviewed literature.
Results

• Large differences in results between RUs.
• Some of the differences are reflective of production practices.
• Some of it is due to changes in soil organic carbon.
Oats

[Bar chart showing KG CO2eq/tonne across different RU values, with categories: SOC, N2O emissions, Ag Chemicals + Seeds, Fertilizer Manufacturing, Direct Energy]
Oats

- Direct Energy: 74.9%
- Fertilizer Manufacturing: 14.9%
- Ag Chemicals + Seeds: 8.2%
- N2O emissions:
Durum

![Bar chart showing greenhouse gas emissions per tonne for different factors in Durum farming.]

- SOC
- N2O emissions
- Ag Chemicals + Seeds
- Fertilizer Manufacturing
- Direct Energy

KG CO2eq/tonne

RU

Wtd average
Soybeans

![Graph showing KG CO2eq/tonne for different years.]

Legend:
- SOC
- N2O emissions
- Ag Chemicals + Seeds
- Fertilizer Manufacturing
- Direct Energy
N$_2$O Emissions

- The global warming potential of N$_2$O is 298 and N$_2$O emissions are a major source of emissions for all crops.
- There is significant regional variation in N$_2$O emission factors across Canada.
  - Precipitation has a strong influence with the higher moisture areas having higher N$_2$O emissions.
$N_2O$ Emissions
Soil Organic Carbon

• Land management changes can cause increases or decreases in SOC.
• Reduced tillage and summerfallow increase SOC.
• Perennial to annual transitions reduce SOC, annual to perennial changes increase SOC but you can’t attribute that to an annual crop.
Soil Organic Carbon

• In the approach used by AAFC it is the net changes in area that drive the results, they don’t track each parcel of land.
  – 1951 is the base year.
  – SOC increases from tillage and SF are only calculated if the practice is still employed
  – SOC decreases from perennial to annual is calculated if the transition happened any time after 1951.
Soil Organic Carbon
Tillage and Summerfallow
Soil Organic Carbon

• Across Canada the changes in SOC from annual/perennial transitions is balanced.
• But there are losses in Central and Eastern Canada and gains in the west.
Comparison to Other Reports

• Each crop is compared to carbon footprints in the peer reviewed literature.
  – Methodology can be different, especially soil carbon approach.
  – Values in this work are often lower than reported by others, especially for western Canadian crops.
  – Tillage practices reduce fuel use and build SOC and the semi-arid climate results in low $N_2O$ emissions.
Data Gaps

• Compared to other carbon footprinting done in Canada this project has benefited from the development of the Canadian fertilizer manufacturing footprints and much more detailed information on fertilizer application rates.
• The quality of data does vary across the country and no one region has a complete data set.
• Canadian data on actual fuel consumption is very limited.
• Pesticide application rates by crop is only available for Ontario and the participation in the last survey was not that high.
• Data on fertilizer application rates ranges from very good to non existent.