

# Quantity and fate of root derived soil carbon produced after a growing season of canola, lentil, pea and wheat in Canadian prairies

Louis-Pierre Comeau <sup>A</sup> and Angela Bedard-Haughn <sup>B</sup>

<sup>A</sup>Department of Soil Science, University of Saskatchewan, Saskatoon, Sk, Canada, Email comeau\_louis@hotmail.com

<sup>B</sup>Department of Soil Science, University of Saskatchewan, Saskatoon, Sk, Canada, Email angela.bedard-haughn@usask.ca

## Abstract

Soil carbon (C) sequestration mitigates climate change and improves lands productivity. Root derived sources of soil C during a growing season is the first step toward C sequestration. The goal of this work was to evaluate the quantity and fate of newly produced soil organic carbon (SOC) captured at the end of a single growing season of canola, lentil, pea and wheat in Canadian Prairie soils. This study was conducted using intact soil cores from two Agriculture and Agri-food Canada Research Stations (Scott and Swift Current). The crop rotations selected at Scott were pea-wheat, canola-wheat and continuous wheat and at Swift Current were lentil-wheat and continuous wheat. Using hermetic plexiglass chambers in a greenhouse, the plants of the first rotation phase were labelled with <sup>13</sup>C<sub>2</sub> weekly for two hours over eight weeks. At the end of the growing season, the cores were broken and the amount of <sup>13</sup>C present in the dissolved organic matter (DOM), the light organic matter fraction, and heavy organic matter fraction was evaluated.

## Key Words

Root derived soil carbon, canola, lentil, pea, wheat, soil organic matter fraction, <sup>13</sup>C labelling, Chernozem

## Introduction

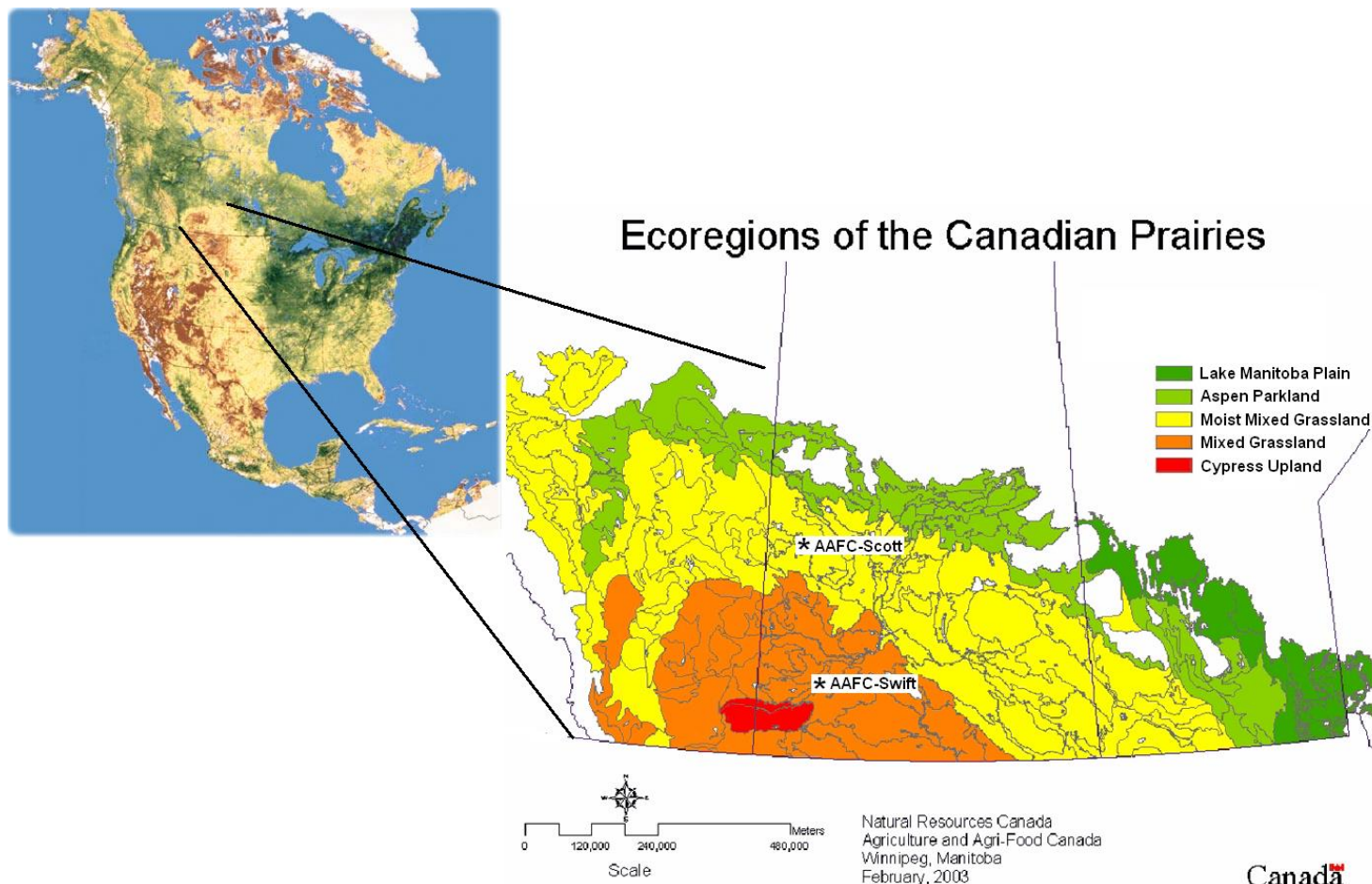
Estimates have shown that since the nineteenth century, 40 to 50 Pg (10<sup>15</sup> g) of carbon (C) has been lost from soil and every year it is estimated that an additional 0.8 Pg C is released due to agriculture (Schlesinger 1995; Desjardins 2008). A recent Canadian study reports that since cultivation of croplands began, 15 to 30 percent of the C originally present in the surface soil layer has been lost, estimated as 1.1 Pg of C. Most of this C had been released into the atmosphere as CO<sub>2</sub>. However, an important part of the C that has been lost from these soils can potentially be regained by restocking this C (Boehm *et al.* 2004; Hengeveld 2008).

Among the 45.5 million hectares of farmland in Canada, 86% (39.1 million hectares) are located in the four western provinces. Therefore, the Canadian prairies have a great potential to mitigate CO<sub>2</sub> emission by increasing soil C storage (Hengeveld 2008). Accumulation of SOC begins with root derived C yet little is known about how much C plant roots are capturing in a single growing season. The aim of this study was to evaluate the quantity and destiny of newly produced soil organic carbon (SOC) captured at the end of a single growing season of canola (*Brassica napus*), lentil (*Lens culinaris*), pea (*Pisum sativum*) and wheat (*Triticum aestivum*) in Canadian prairies soils.

## Materials and Methods

### *Study sites and soil collection*

This greenhouse study was carried out with intact soil cores (39cm by 20.3cm i.d.) from Agriculture and Agri-Food Canada Research Stations at Scott (AAFC-Scott) and at Swift Current (AAFC-Swift) (Figure 1). The AAFC-Scott station is located in the Moist Mixed Grassland Ecoregion of Saskatchewan Canada where the dominant soils are loamy textured Dark Brown Chernozems. The AAFC-Swift station is located in the Mixed Grassland Ecoregion, where the climate is considerably drier and the dominant soils are sandy loam textured Brown Chernozems (Acton and Ellis 1978; Ayres *et al.* 1985). At AAFC-Scott soil cores were collected from continuous wheat, pea-wheat and pea-canola rotations. At AAFC-Swift soil cores were collected from continuous wheat and lentil-wheat rotations. All rotations had completed a wheat phase of the rotation the previous year.



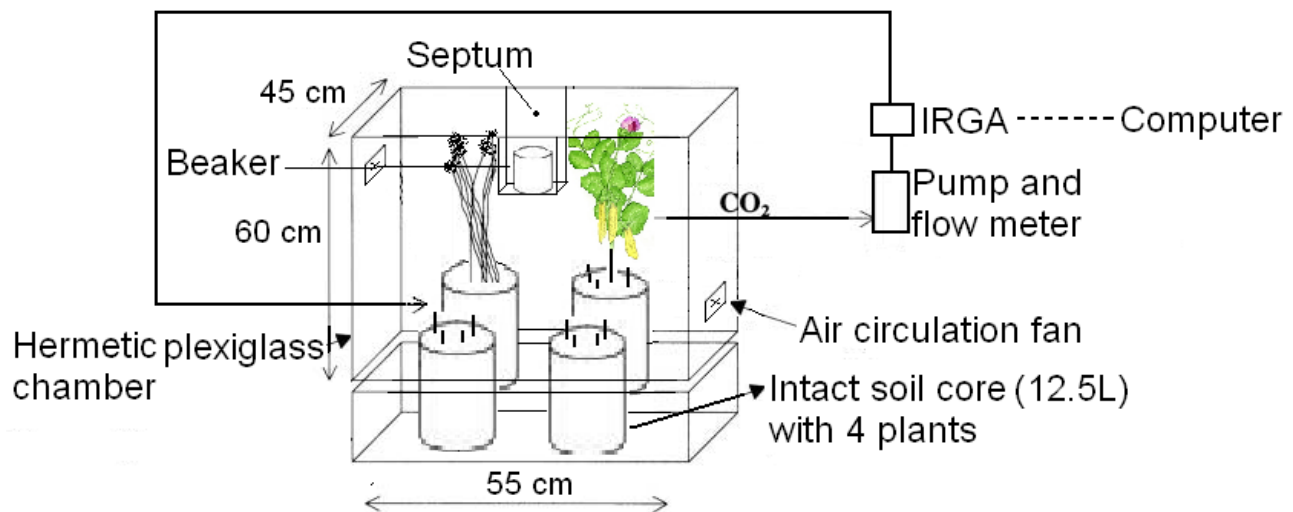
**Figure 1. Map of Ecoregions of the Canadian Prairies. Natural Resources Canada, Agriculture and Agri-Food Canada.**

*Plant labelling*

Pea, lentil, canola and wheat (from AAFC-Scott and AAFC-Swift) were grown (in its respective soil core) to maturity and pulse labelled with isotopic carbon 13 ( $^{13}\text{C}$ ) under controlled greenhouse conditions. Three plots were selected for each crop rotation, two replicas were made for each plot and a control (no labelling) was made for each replica (table 1). Four plants were grown in each soil core. Plants were watered to field capacity every second day. In order to prevent soil biota and soil organic matter (SOM) dynamic alterations no agrochemical were used during the experiment. Labelling was accomplished in polymethyl methacrylate chambers (figure 2) from Sangster (2009 unpublished). Labelling was done weekly for 2 h starting 20 days after germination and continuing to the end of embryogenesis (8 label sessions). The soil surface was isolated from the enriched atmosphere during labelling. The atmospheric enrichment during the labelling session was 33 atom%  $^{13}\text{CO}_2$  and the total  $\text{CO}_2$  concentration was maintained around the current atmospheric concentration (380-430 ppm; IPCC 2007). The  $\text{CO}_2$  was devolved into the chamber by injecting a saturated solution of  $\text{NaHCO}_3$  (33%  $^{13}\text{C}$ ) into a beaker with 12M HCl. Total  $\text{CO}_2$  concentration was monitored with an infrared gas analyzer (IRGA) (S151 Infrared  $\text{CO}_2$  Analyzer, Qubit Systems, Kingston, Ontario).

**Table 1. Number of field plot and replica for each crop rotation**

Site	Crop rotation	Number of field plot	Number of replica by plot	Number of control by plot	Number of soil cores analysed
AAFC-Scott	continuous wheat	3	2	1	9
	canola-wheat	3	2	1	9
	pea-wheat	3	2	1	9
AAFC-Swift	continuous wheat	3	2	1	9
	lentil-wheat	3	2	1	9



**Figure 2. Design of stable  $^{13}\text{C}$  labelling chamber, with four soil cores per chamber and four plants per core.**

#### Soil $^{13}\text{C}$ analyses

At harvest, soil samples (0-15, 15-30 cm) were collected from each soil core. Soil organic matter (SOM) was fractionated into dissolved organic matter (DOM), light fraction (LF) ( $0-1.7 \text{ g cm}^{-3}$ ), and heavy fraction (HF) ( $>1.7 \text{ g cm}^{-3}$ ) (Bird 2002; Chantigny 2007). For every SOM fraction,  $^{13}\text{C}$  was analysed by isotope ratio mass spectrometer (Bird 2003). Natural abundance of  $^{13}\text{C}$  in each SOM fraction was determined from the control soil cores. The comparative amount of newly produced SOC captured by the different plants was analysed with a general linear model (GLM) using the statistical program R (Foundation for Statistical Computing version 2.8.1) (Helbig 2008).

#### Anticipated Significance

The results of this work will allow a better understanding of the biotic processes that control the carbon cycle, will aid to elaborate models of  $\text{CO}_2$  fluxes, and will improve the understanding of the crop-specific dynamics of SOC, which play a role in greenhouse gas emissions and mitigation.

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