# Verifying soil organic carbon sequestration by $C_4$ perennial biomass crops using $^{13}C$ natural abundance technique in southern Ontario, Canada

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ONTARIO BIOMASS PRODUCERS CO-OP

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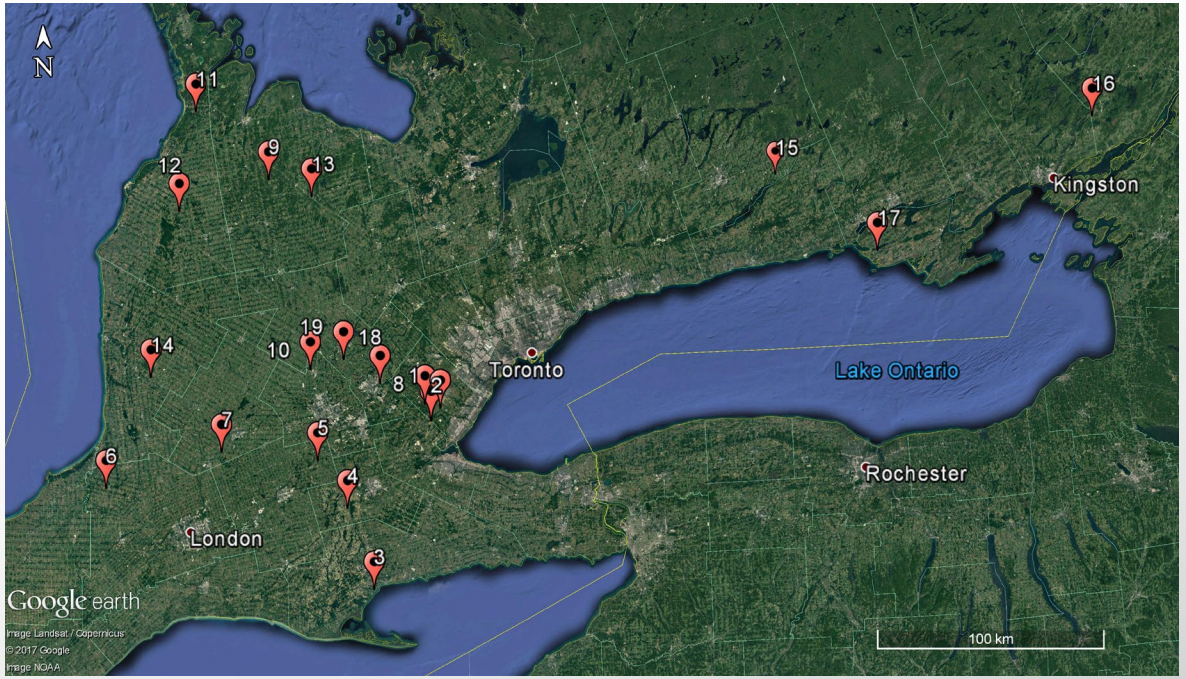
# Long-term Research….

- quantify SOC rate of increase in biomass fields
  2016 SOC data: - base line data (Graham at al., 2018)

  2020 - sampled in 32 different fields (11 different sites) including,

  Switchgrass – 11
  Miscanthus – 09
  Agriculture- 06
  Woodlot – 06




- quantify SOC and N in different soil aggregate fractions
  dry sieving method

- assess carbon contribution from the C4 biomass crop to the soil
  - δ13C isotope analysis
  - baseline data (2016) – 3 sites
  - contribution after 4 years (2020)




3 study sites:

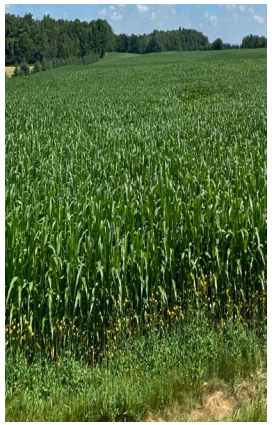
a) Elora Research Station (ERS): (2008-2019)

b) Guelph Turfgrass Institute (GTI): (2009-2020)

c) Burlington Mabel May Farm: (2016-2020)

land was under agriculture crop production with annual crop rotation (used as a reference field).

PBC establishment on a certain portion of the land



Corn (*Zea mays*)
$C_4$ crop

Soybean (*Glycine max*)
$C_3$ crop

Wheat (*Triticum aestivum*)
$C_3$ crop

Miscanthus (*Miscanthus spp.*)
$C_4$ crop

Switchgrass (*Panicum virgatum*)
$C_4$ crop

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# Quantifying soil organic carbon stocks in herbaceous biomass crops grown in Ontario, Canada

**Jordan Graham · Paul Voroney · Brent Coleman · Bill Deen · Andrew Gordon · Mahendra Thimmanagari · Naresh Thevathasan**

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**Abstract** Nineteen farms growing herbaceous biomass crops, switchgrass (*Panicum virgatum*) and miscanthus (*Miscanthus* spp.), were sampled for soil organic carbon (SOC) across Ontario, Canada in 2016. Switchgrass and miscanthus fields were sampled in miscanthus land-uses, which contained $80.51 \pm 7.74$ and $83.36 \pm 8.97$ Mg C ha$^{-1}$, respectively. The mean SOC stock calculated for switchgrass was $85.30 \pm 7.14$ Mg C ha$^{-1}$ and was not significantly different ($p > 0.05$) when compared with the SOC

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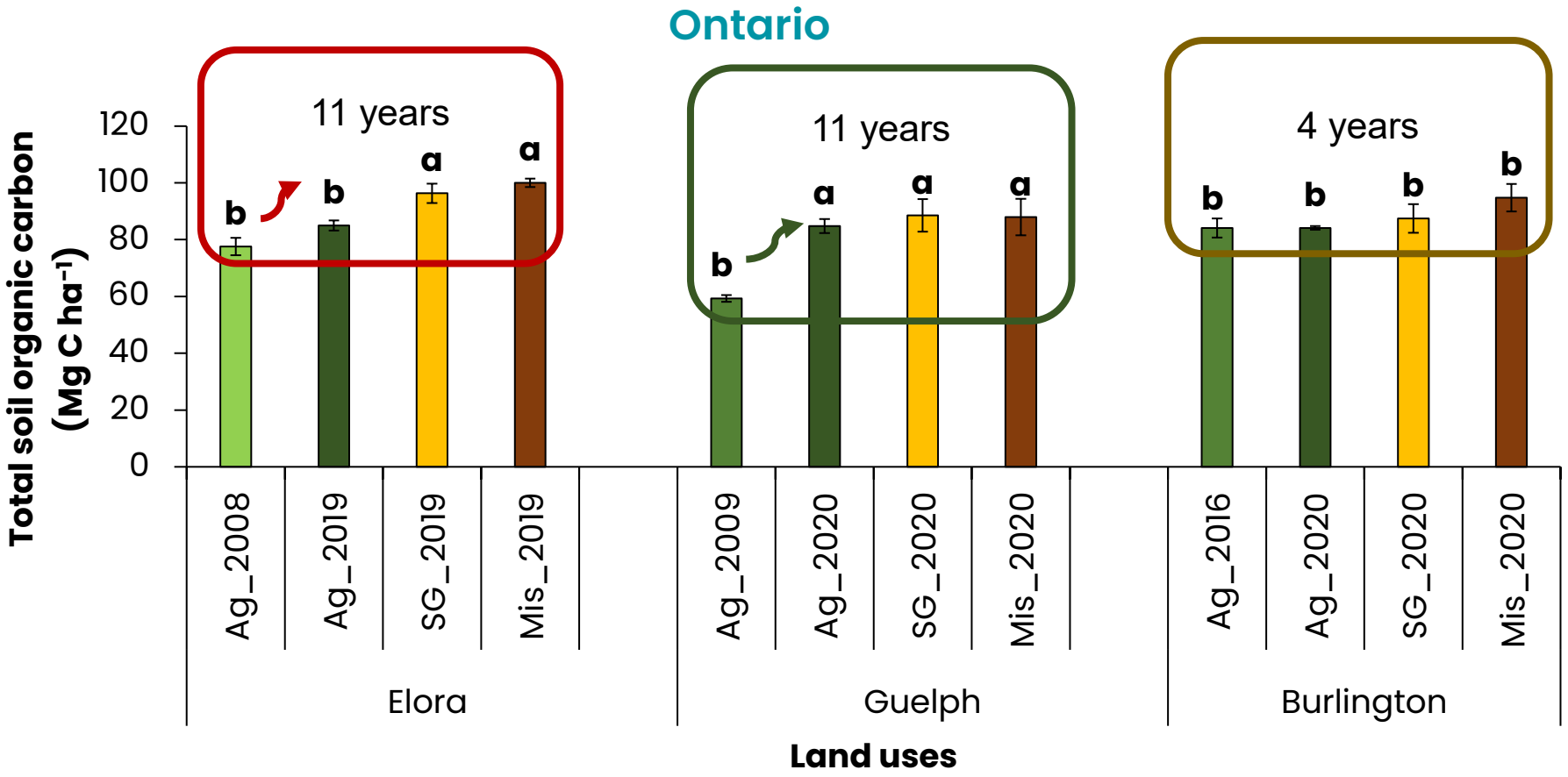
# Results

## Total soil organic carbon in SG, Mis and Ag fields in Elora, Guelph and Burlington, Ontario




- **SOC sequestration rate**
  SG: 0.85-2.65 Mg C $ha^{-1}$ $y^{-1}$
  Mis: 2.04 - 2.65 Mg C $ha^{-1}$ $y^{-1}$

| Locations | SOC Stock Gain (Mg C $ha^{-1}$) | | | Years of Crop Cultivation (y) | Mean Annual SOC Sequestration Rate (Mg C $ha^{-1}$ $y^{-1}$) | | | Sequestered $CO_2$ Equivalent (Mg $CO_2$ $ha^{-1}$) | | | Potential SOC Stock Gain (Mg C $ha^{-1}$) | | | Potential $CO_2$ Sequestration (Mg $CO_2$ $ha^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ag | SG | Mis | Ag/SG/Mis | Ag | SG | Mis | Ag | SG | Mis | Ag | SG | Mis | Ag | SG | Mis |
| **Elora** | 7.4 | 18.7 | 22.4 | 11 | 0.67 | 1.70 | 2.04 | 27.6 | 68.6 | 82.2 | 80.3 | 69.0 | 65.3 | 294.7 | 253.2 | 239.7 |
| **Guelph** | 25.5 | 29.2 | 28.6 | 11 | 2.32 | 2.65 | 2.6 | 93.6 | 107.2 | 105.0 | 69.5 | 65.9 | 66.5 | 255.1 | 241.9 | 244.1 |
| **Burlington** | 1.7 | 3.4 | 10.6 | 4 | 0.46 | 0.85 | 2.65 | 6.2 | 12.5 | 39.0 | 34.0 | 32.3 | 25.1 | 124.8 | 118.5 | 92.1 |

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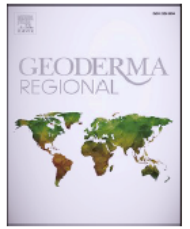


# The effect of land-use conversion from agriculture to perennial biomass crops and nitrogen fertilizer on soil organic carbon stock in southern Ontario, Canada

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ABSTRACT

Switchgrass [*Panicum virgatum*, (SG)] and miscanthus [*Miscanthus* spp., (Mis)] are perennial biomass crops (PBCs) commonly grown in Ontario, Canada. By the integration of PBCs on marginal/degraded agricultural (Ag) [illegible]as been reported in the scientific literature. [illegible] contribute to Canada's goal to reach net-zero greenhouse gas emissions by 2050. However, long-term field research (>10 years) to clearly demonstrate this

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# Objective

to estimate the contribution of $C_4$ derived SOC in the fields of switchgrass (SG), miscanthus (Mis) and agricultural crop (annual crop rotation) (Ag)

## $^{13}C$ natural abundance technique:

- concentration of a stable isotope as it occurs in nature
    - $^{12}C$ and $^{13}C$ : two most abundant stable isotopes of C
- utilize the difference in $^{13}C$ values ($\delta^{13}C$) of $C_3$ and $C_4$ plants to identify the source, pools and fate of organic C in soils
- $C_3$ or $C_4$ vegetation contain SOM with $\delta^{13}C$ of −27‰ or −13‰, respectively
- $\delta^{13}C$ values allow either group of plants to act as a tracer

# Sample collection

Soil sample collection in 2008/2009

- Elora (Ag) - 2008
- Guelph (Ag) - 2009

Baseline SOC

sample collection in 2016

- Guelph (7 years of PBCs)
- Burlington (Ag)

$\delta^{13}C$ (‰) values

- Guelph (7 years of PBCs)

Burlington (Baseline SOC)

**A**

$C_4$ crop derived C include corn derived & PBCs (7 years in Guelph)

sample collection in 2019/2020

- Elora (11 years of PBCs) -2019
- Guelph (11 years of PBCs) -2020
- Burlington (4 years of PBCs) - 2020

$\delta^{13}C$ (‰) values

- Elora (11 years of PBCs)
- Guelph (11 years of PBCs)
- Burlington (4 years of PBCs)

**B**

$C_4$ crop derived C include corn derived & PBCs (11 years in Elora and Guelph, 4 years in Burlington)

**B-A= C**

C: $C_4$ crop derived C include only PBCs (4 years) Guelph

# $C_4$ crop's contribution ($C_4$ derived SOC) to total SOC

δ13C (‰) signatures, total soil organic carbon (SOC) stocks and calculated contribution of $C_4$ derived SOC to the total SOC in Guelph, Elora and Burlington, Ontario in 2019/2020.

| Location | Land-use | Establishment (year) | $\delta^{13}C_{SOC}$ (‰) | Total SOC (Mg C $ha^{-1}$) | $C_4$ derived SOC (Mg C $ha^{-1}$) | $C_4$ derived SOC (%) | $C_3$ derived SOC (Mg C $ha^{-1}$) |
|---|---|---|---|---|---|---|---|
| Guelph | Ag | N/A | -24.21 | 84.8 (± 2.47) | 15.9 (± 0.35)b | 19 | 68.9 (± 0.35) |
| Guelph | Mis | 2009 | -22.58 | 87.9 (± 6.43) | 26.9 (± 0.16)a | 31 | 61.0 (± 0.16) |
| Guelph | SG | 2009 | -22.70 | 88.5 (± 5.72) | 26.4 (± 0.08)a | 30 | 62.1 (± 0.08) |
| Elora | Ag | N/A | -23.05 | 85.0 (± 1.80) | 22.7 (± 0.04)z | 27 | 62.3 (± 0.04) |
| Elora | Mis | 2008 | -19.83 | 100.0 (± 1.48) | 49.8 (± 0.23)x | 50 | 50.2 (± 0.23) |
| Elora | SG | 2008 | -21.08 | 96.3 (± 3.44) | 39.6 (± 0.10)y | 41 | 56.7 (± 0.10) |
| Burlington | Ag | N/A | -24.53 | 85.8 (± 0.65) | 14.2 (± 0.07)s | 17 | 71.6 (± 0.07) |
| Burlington | Mis | 2016 | -25.30 | 94.7 (± 4.86) | 11.0 (± 0.09)t | 12 | 83.7 (± 0.09) |
| Burlington | SG | 2016 | -25.59 | 87.5 (± 5.04) | 8.4 (± 0.15)u | 10 | 79.1 (± 0.15) |

$C_4$ derived SOC:

Mis > SG > Ag in Elora and Guelph (11 years)

Ag > Mis > SG in Burlington (4 years)

# $C_4$ derived SOC stock contribution from biomass crops in 4 years of cultivation to total SOC stock in Guelph, Ontario.

| Site | Land use | $C_4$ derived SOC stock in 2016 (Mg C $ha^{-1}$) A | $C_4$ derived SOC stock in 2020 (Mg C $ha^{-1}$) B | $C_4$ derived SOC stock change (2016-2020) (Mg C $ha^{-1}$) | Years of cultivation (y) | $C_4$ derived SOC sequestration rate (Mg C $ha^{-1}$ $y^{-1}$) |
|---|---|---|---|---|---|---|
| Guelph | SG | 23.3 (± 0.55)**b** | 26.4 (± 0.08)**a** | 3.1 (± 0.60) | 4 | 0.8 (± 0.15) |
| Guelph | Mis | 24.3 (± 1.51)**y** | 26.9 (± 0.16)**x** | 2.6 (± 1.51) | 4 | 0.7 (± 0.38) |
| Guelph | Ag | 14.5 (± 0.99)s | 15.9 (± 0.35)s | 1.4 (± 0.35) | 4 | 0.4 (± 0.20) |

- $C_4$ SOC stock:
  - include corn derived & PBCs
  - contribution increased

B - A

- last 4 years of PBCs cultivation
  - $C_4$ stock: only from PBCs

- SG and Mis; ~double the rate of Ag
  - In Ag; only 45-54% of the $C_4$ derived SOC observed in SG and Mis

Converting low productive Ag land to PBC -> increases SOC -> best management practice and a tool for climate change mitigation

Please visit the following link for all publications, videos and factsheets:

https://onforagenetwork.ca/ontario-biomass-producers-co-operative-inc/resources-from-naresh-thevathasan/

**Thank you!**

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