EVALUATION OF STRATEGIES TO REDUCE ENVIRONMENTAL IMPACTS OF MAIZE PRODUCTION IN THE QUEBEC CONTEXT USING THE STICS MODEL FOR LIFE CYCLE ASSESSMENT

XIII STICS seminar - 13-14-15 and 16 November 2023

Aérocampus Aquitaine, Latresne

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Agriculture et Agroalimentaire Canada | Agriculture and Agri-Food Canada | RQRAD | AgroParisTech | Université Laval

CONTEXT AND OBJECTIVS

Feed production

Main contributor to environmental impacts of pig and poultry production

(MacLeod et al. 2013 ; Andretta et al., 2021)

Feeding strategies

Reduction of impacts : incorporation of new raw materials to replace soybean

(Cappelaere et al., 2021)

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Quebec context

Local production

Soybean from North America with low environmental impact

Maize produced in Quebec with hight environmental impact

Low diversity of feedstuffs

High costs and low production volumes

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Low diversity of feedstuffs

High costs and low production volumes

→ **Identifying other strategies is necessary**

Strategies

Diversification of rotations
(cover crops, …)

Rationalisation of fertilization

Reduction of tillage

Strategies

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(cover crops, …)

Rationalisation of fertilization

Reduction of tillage

Evaluation → Life cycle assessment → Standardized indicators

Strategies

Diversification of rotations (cover crops, ...)

Rationalisation of fertilization

Reduction of tillage

Evaluation → Life cycle assessment → Standardized indicators

Inventory data

Inputs and machinery (transportation, manufacturing, ...) → Databases

On field emissions, leaching, yields, ... → STICS model

General objective

- Produce references data on environmental impacts of maize production in the Quebec context to perform LCAs of animal production

Sub-objective

- Produce data on field emissions (GHG), nitrates leaching and yields of maize production in the Quebec context, to use these outputs to perform LCAs

METHODOLOGY

Definition of scenarios to model

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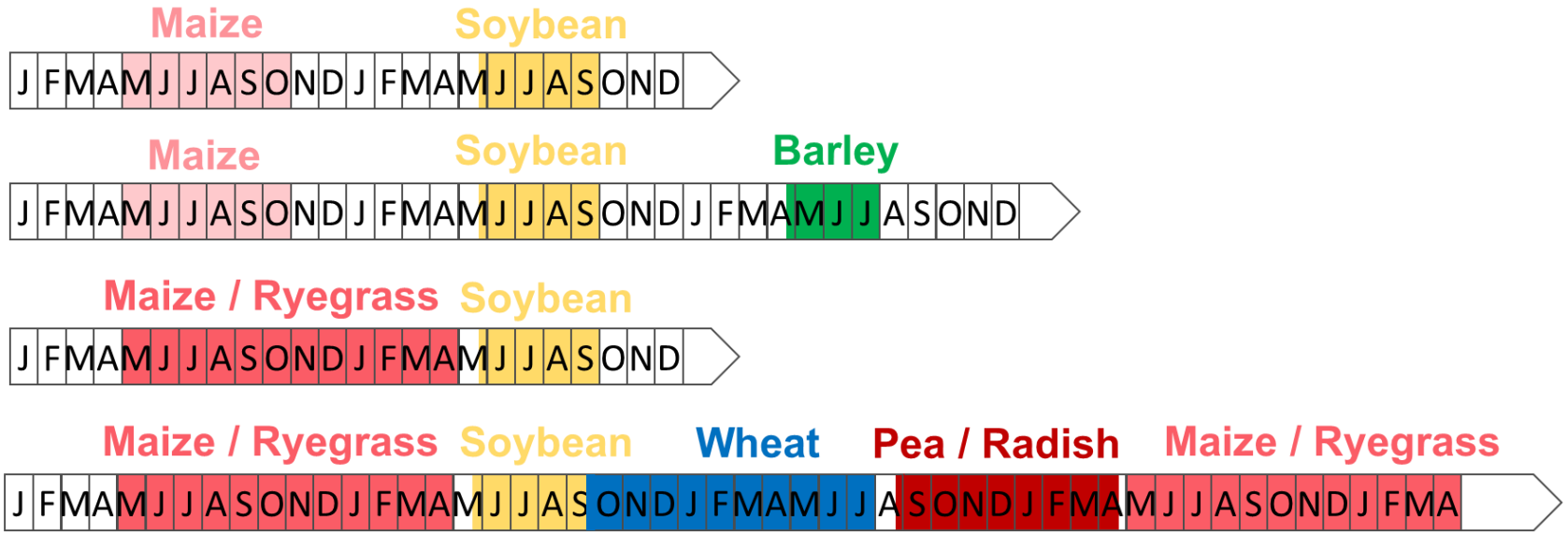


Definition of scenarios to model

Rotations

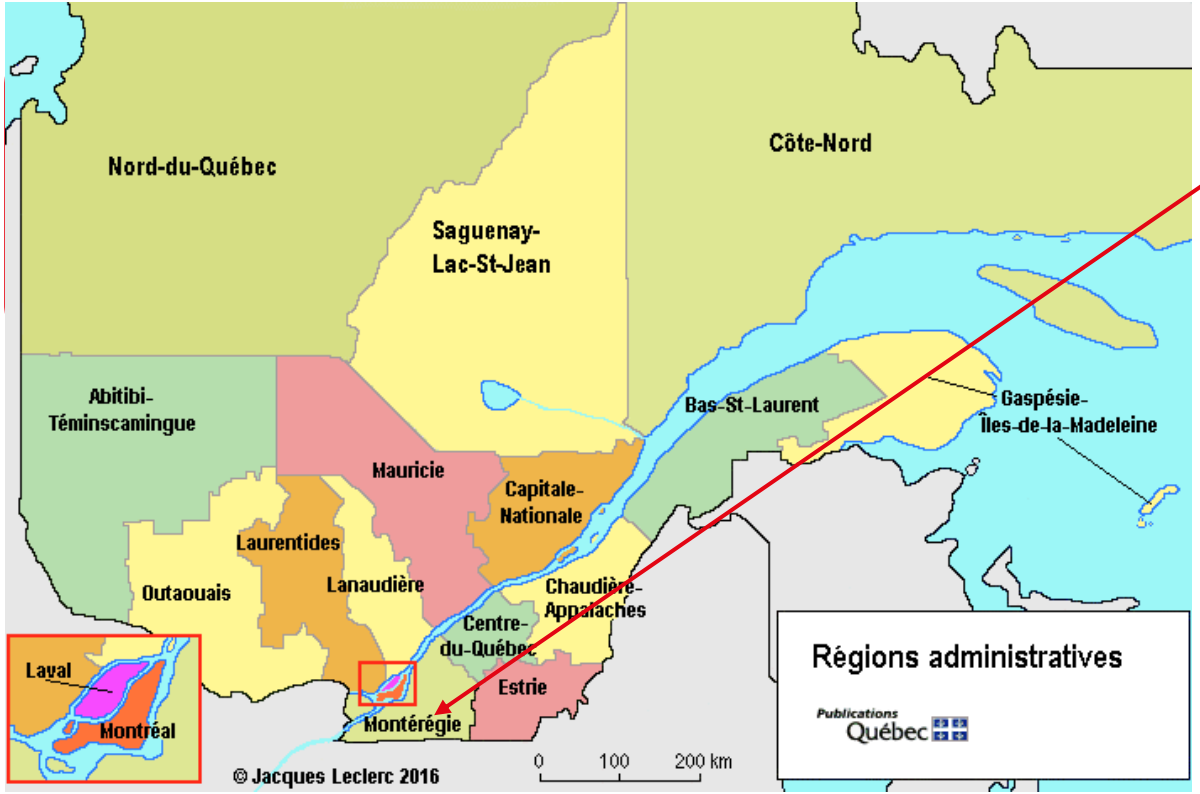
Maize-Soybean

Maize-Soybean-Barley

Maize/RG-Soybean

Maize/RG-Soybean-Wheat-Pea/Radish

Definition of scenarios to model



Montérégie region

Annual average temperature: 6,7 °C

Annual average rainfall:
973 mm

62% of maize production area

Definition of scenarios to model

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Rotations
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Maize-Soybean-Barley
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Soil preparation
Conventional tillage
Reduced tillage
No-till

Montérégie region
Annual average temperature: 6,7 °C
Annual average rainfall: 973 mm
62% of maize production area

Soils
Sandy Loam
Loam
Clay Loam

Fertilizer
Urea

→ 36 scenarios

Use of STICS model

Inputs

Interventions

Fertilization

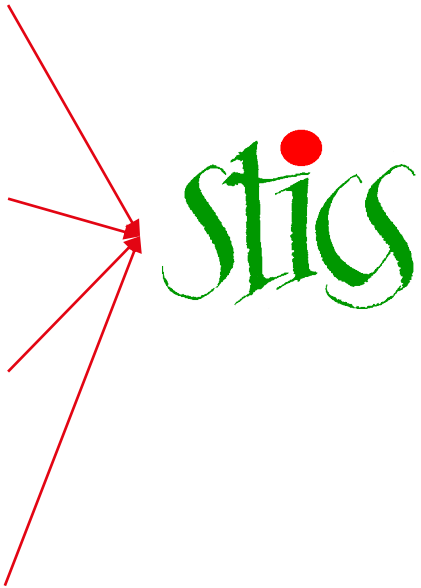
CRAAQ[1] references and experts

Adaptation according the type of soil and the previous crop

Soils
(Qian et al., 2019)

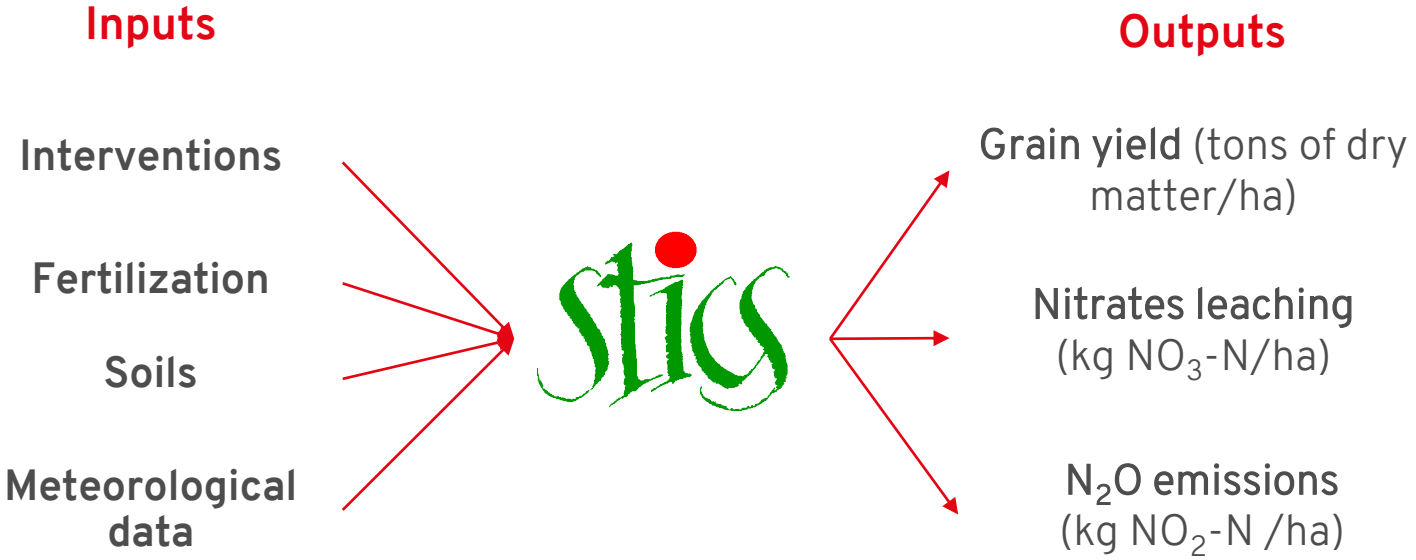
Meteorological data

Weather station
Environment Canada

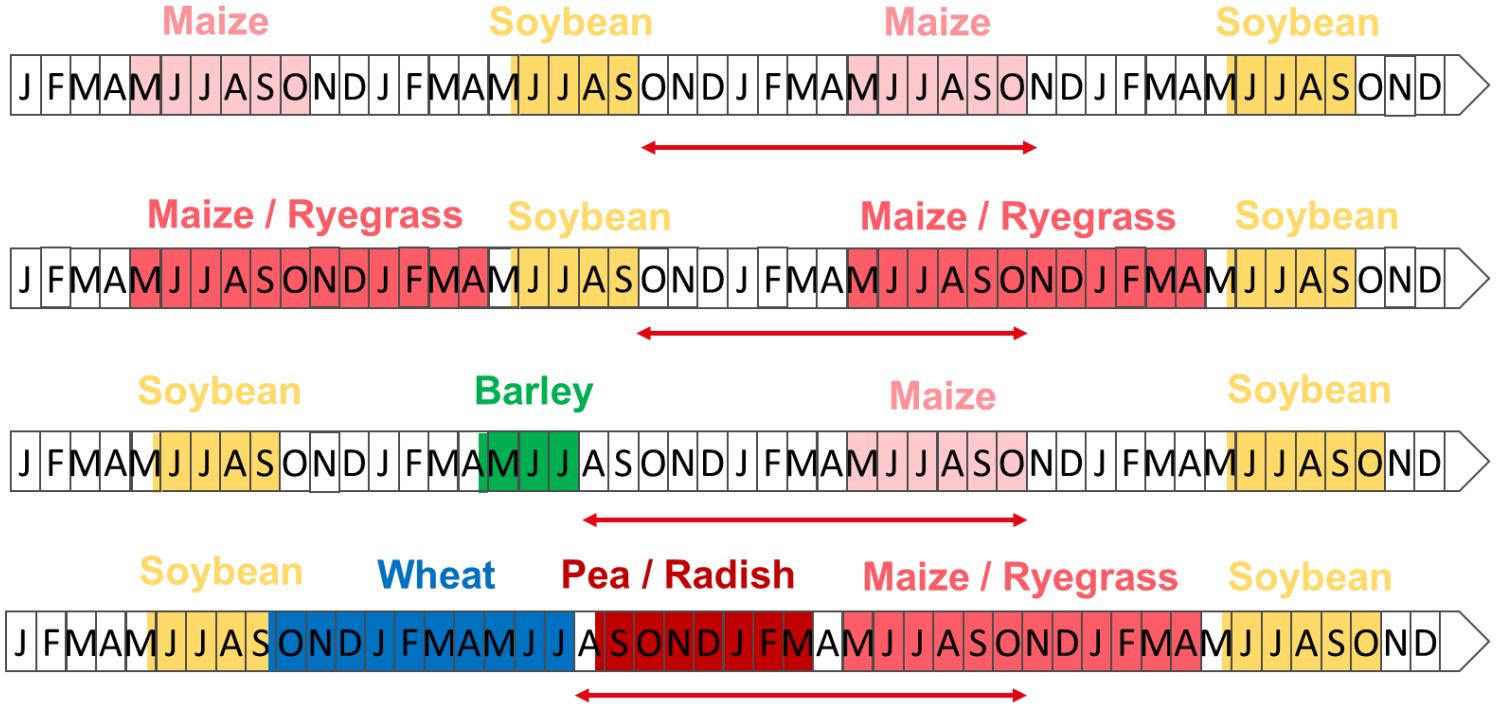


[1]Centre de Référence en Agronomie et Agroalimentaire du Québec

Use of STICS model



Use of STICS model



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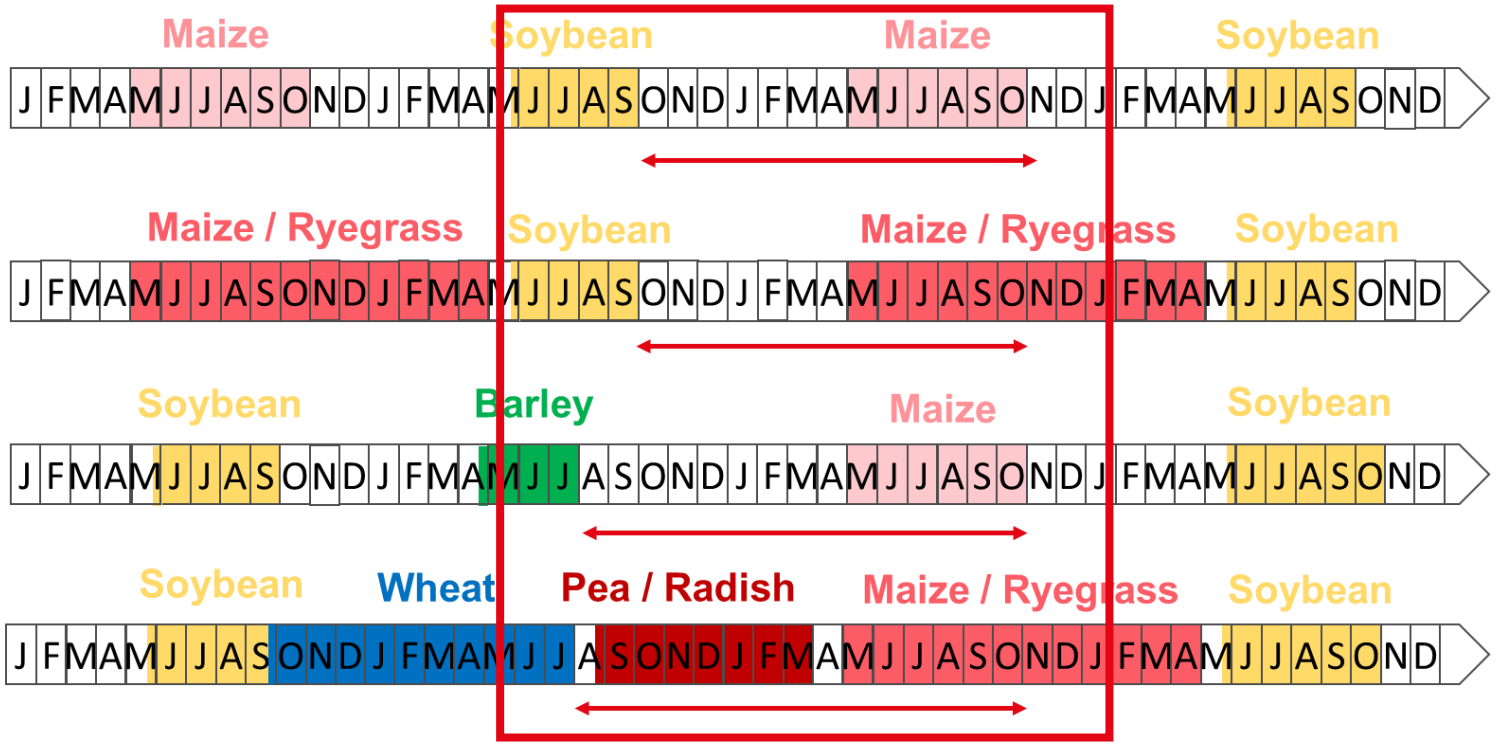
Use of STICS model



Average cumulative values over the period « harvest to harvest » for the common years in the different rotations

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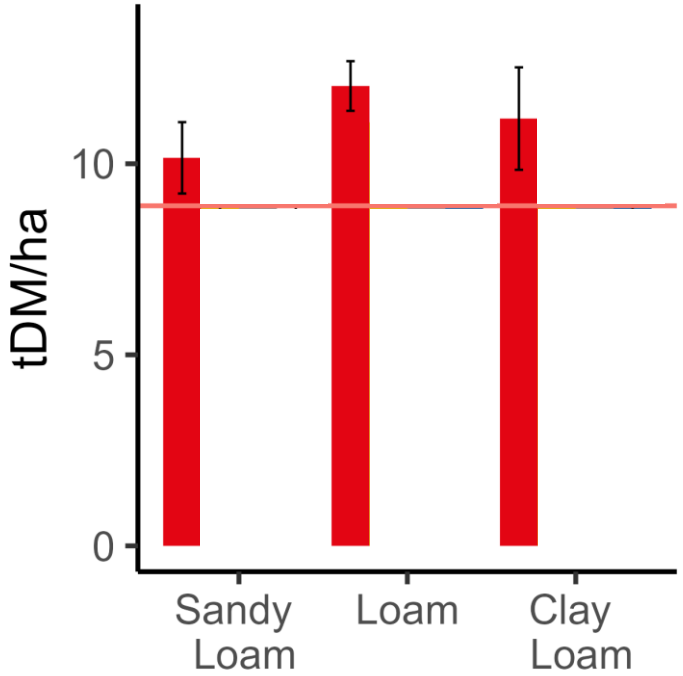
RESULTS

Grain yield for maize – Effect of soil and crop rotation



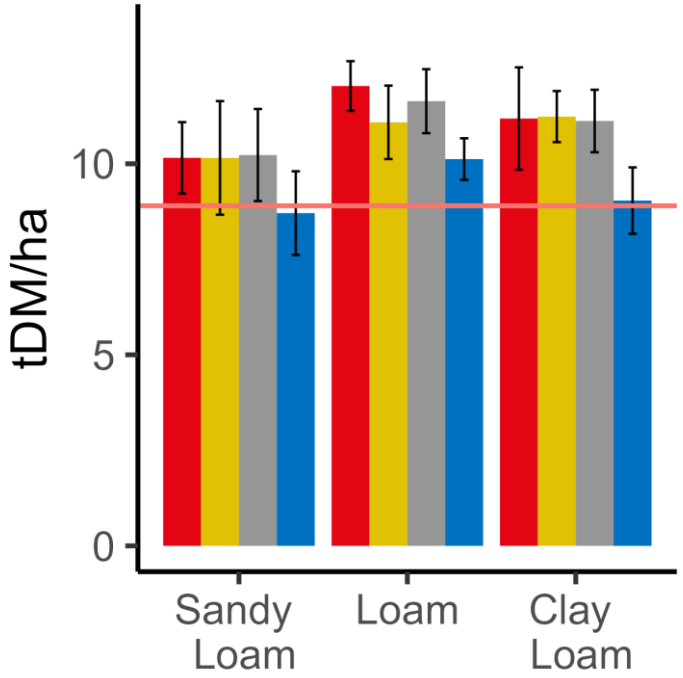
Three-years average grain yields for maize

Maize-Soybean

Financière Agricole du Québec

- Grain yields slighty higher than observed references
  - 1 weather station
  - No diseases or pests

Grain yield for maize – Effect of soil and crop rotation



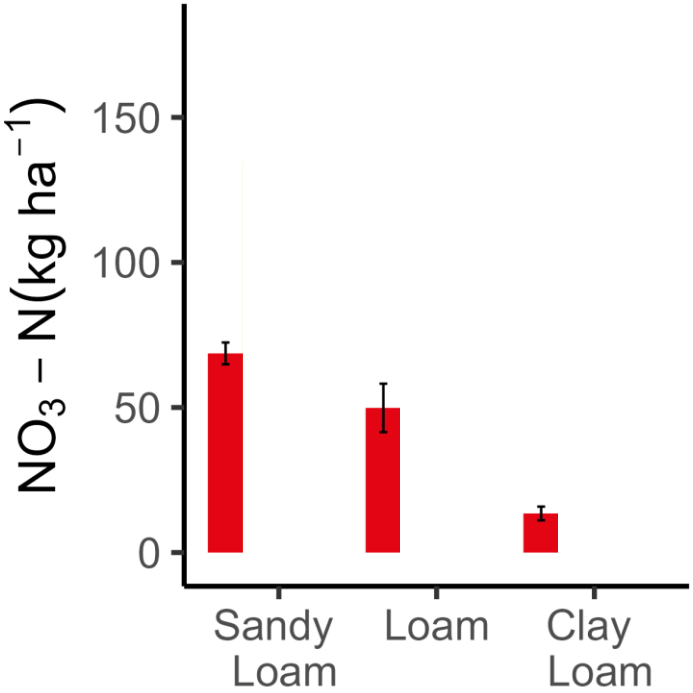
Three-years average grain yields for maize

Maize-Soybean
Maize-Soybean-Barley
MaizeRG-Soybean
MaizeRG-Soybean-Wheat-Pea/Radish

— Financière Agricole du Québec

- Lower yields simulated for the most diversified rotation on a loam and clay loam

Nitrates leaching for maize – Effects of soil and crop rotation

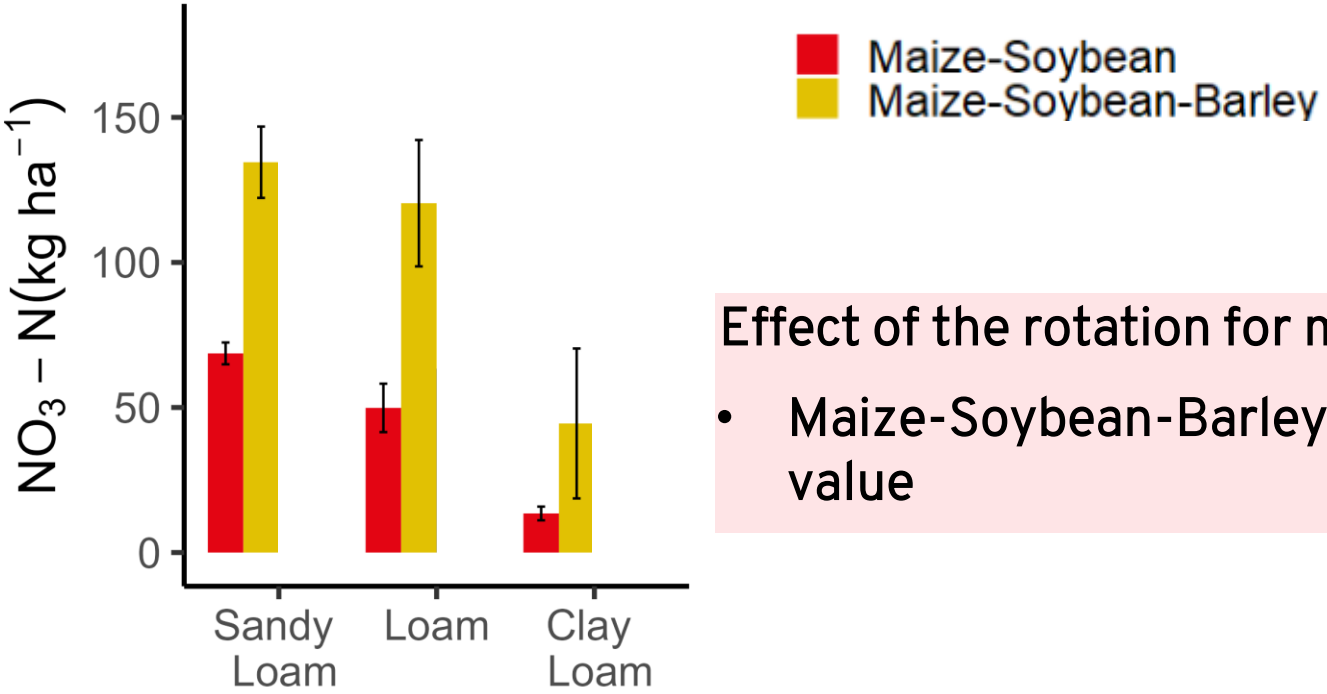


Three-years average cumulative amount of nitrates leached for maize

Effect of soil :

Highest values predicted for the sandy loam

Nitrates leaching for maize – Effects of soil and crop rotation



Three years average cumulative amount of nitrates leached for maize

Effect of the rotation for maize production:

- Maize-Soybean-Barley : higher average value

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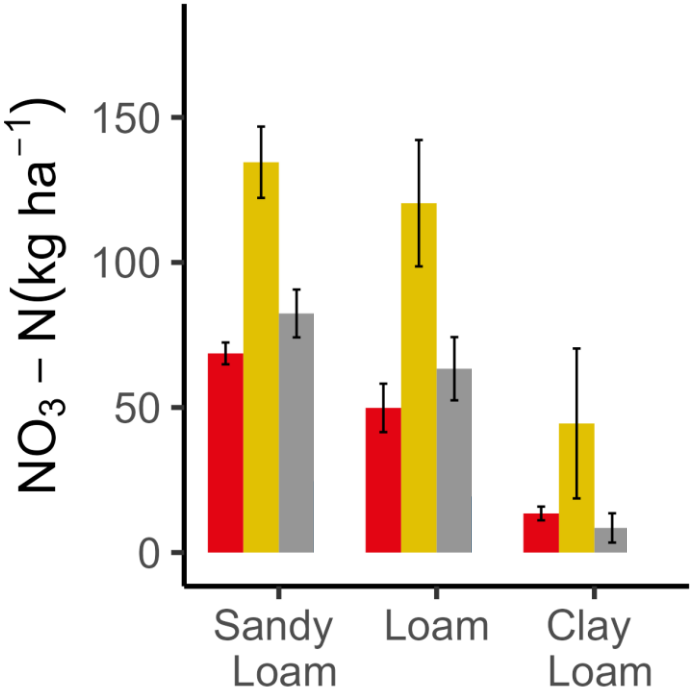

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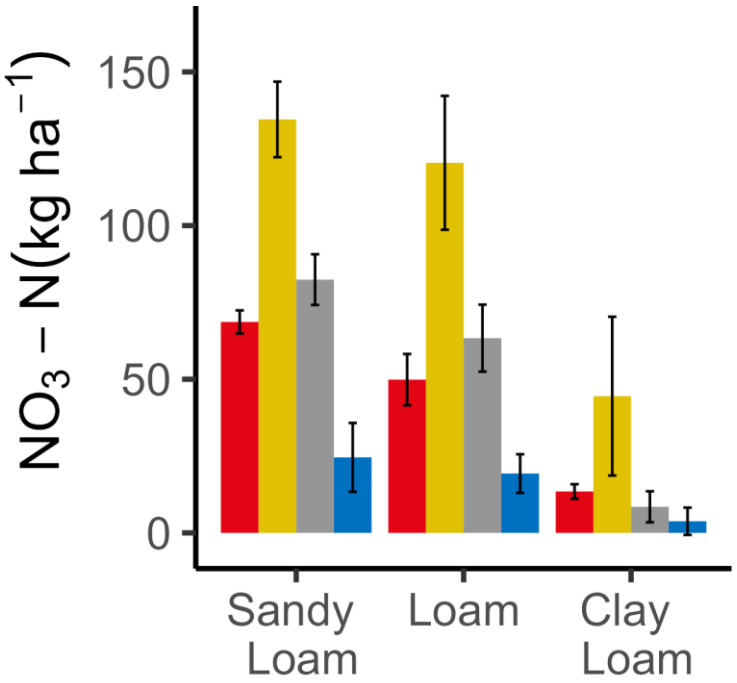

Three years average cumulative amount of nitrates leached for maize

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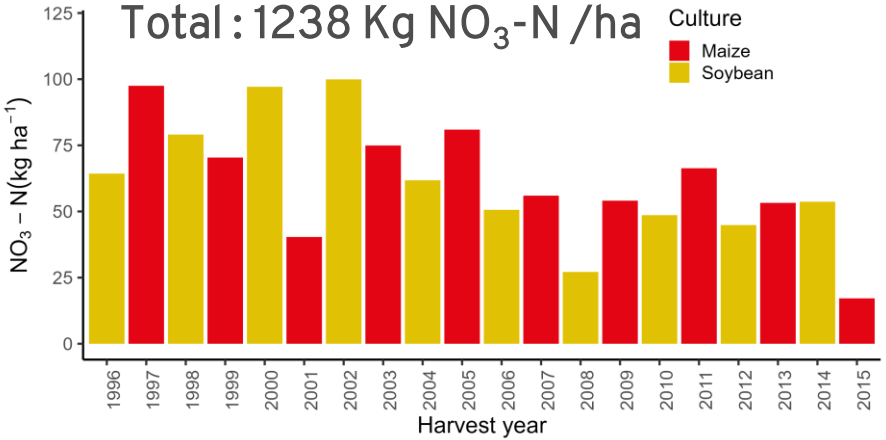
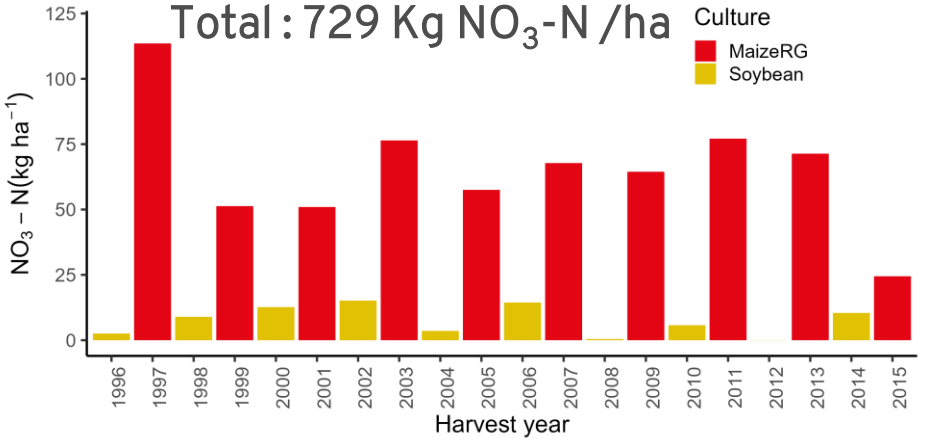
Effect of the rotation for maize production:

- Maize-Soybean-Barley : higher average value
- MaizeRG-Soybean : no reduction of nitrates leaching
- MaizeRG-Soybean-Wheat-Pea/Radish : reduction of nitrates leaching

Nitrates leaching – Effect for the entire rotation



Maize-Soybean



MaizeRG-Soybean

Loam – Conventional tillage

Nitrates leaching

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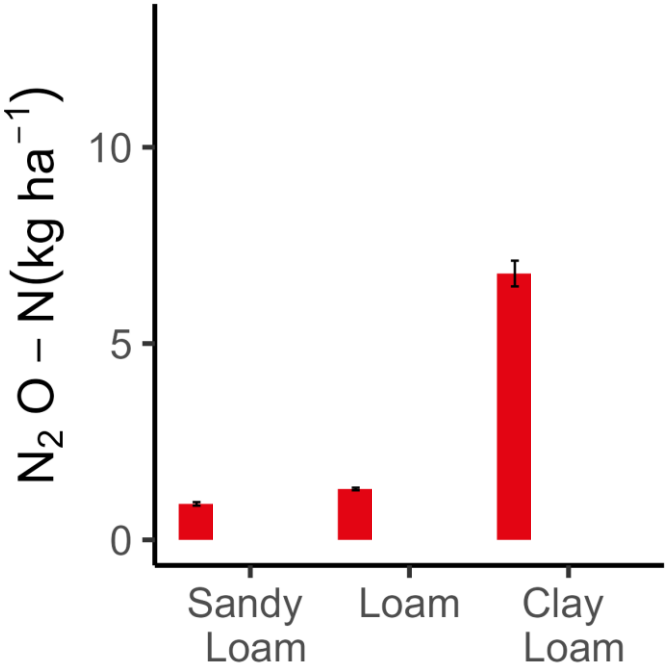
N_2O emissions for maize – Effect of soil and crop rotation

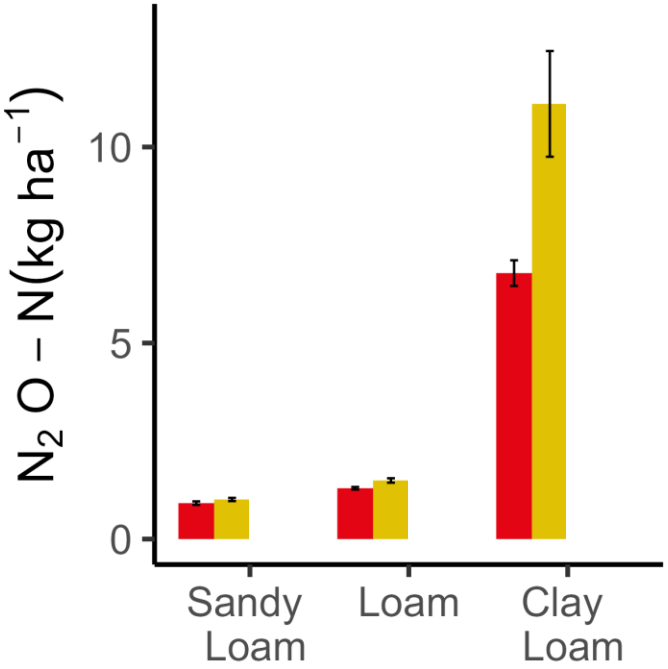


Three-years average cumulative amount of N_2O-N emitted from soil for maize

Effect of soil :

- Highest values predicted on a clay loam

N_2O emissions for maize – Effect of soil and crop rotation



Three-years average cumulative amount of N_2O-N emitted from soil for maize

Effect of the crop rotation for maize production :

- Maize-Soybean-Barley : higher values predicted on a clay loam

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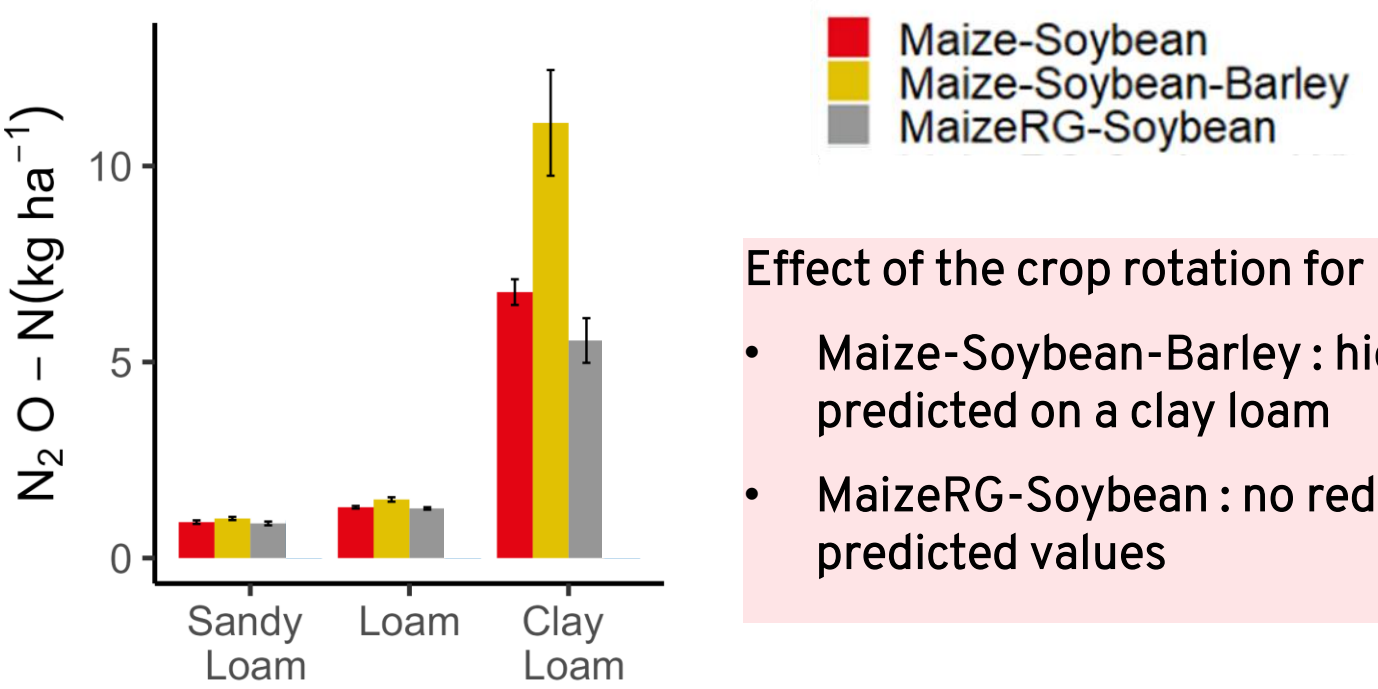

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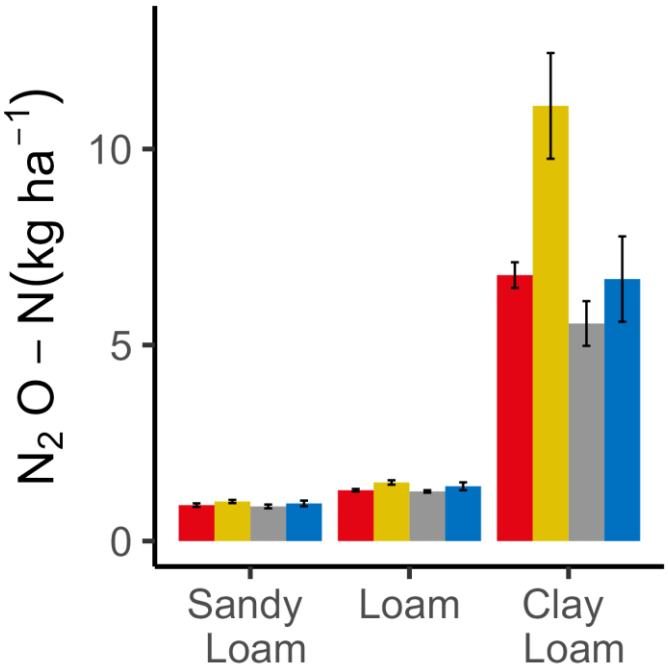

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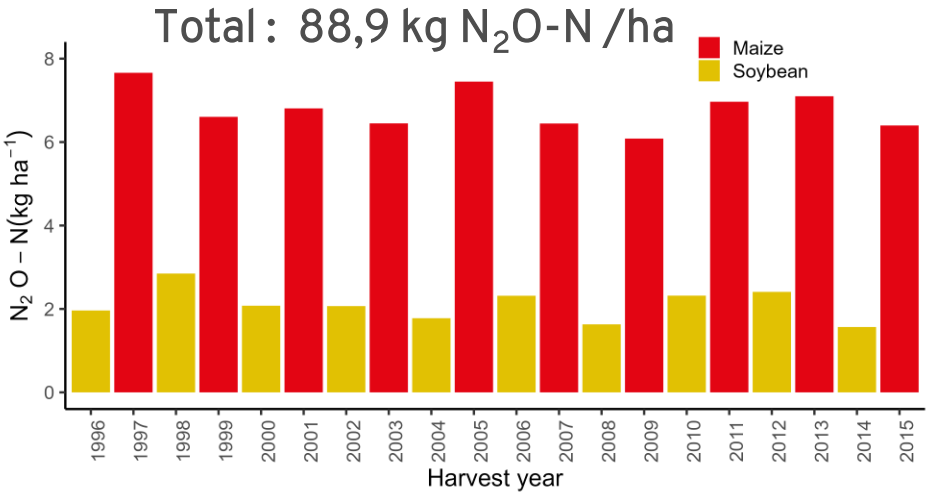
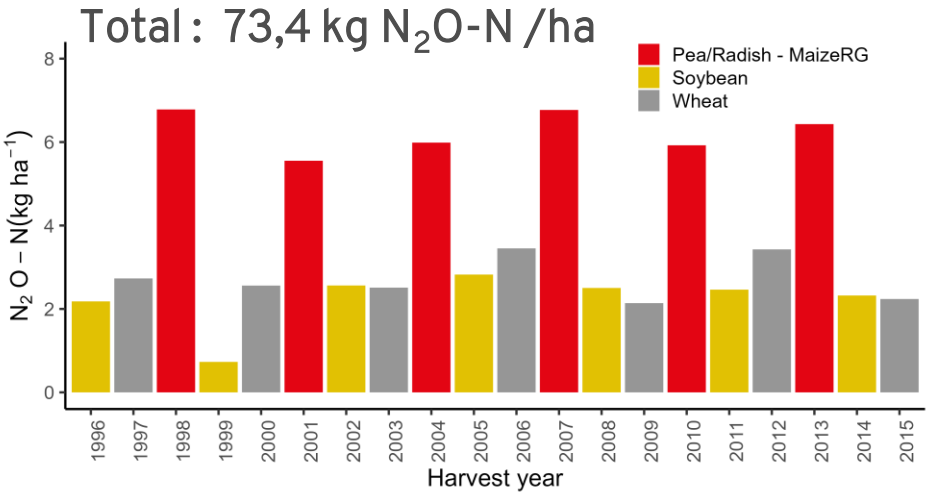


Maize-Soybean



MaizeRG-Soybean-Wheat-Pea/Radish

Clay Loam – Conventional tillage

N_2O emissions

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CONCLUSION AND PERSPECTIVES

Conclusion

- Interest of the STICS model to represent the diversity of pedoclimatic production contexts in Quebec
- Effect of diversification for the entire rotation

Perspectives

- LCAs performed: values consistent with references for conventionnal practices
- Modelling results from STICS (yields, leaching) reflected in LCAs results
- Simulation / LCAs of novel crops in other regions (ex : Bas-Saint-Laurent)
- LCAs for animal production

Thank you for your attention

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