Chaire INDUSTRIELLE CRSNG - UQAT - UQAM en aménagement forestier durable

Forêts, Faune et Parcs Québec

UQAT UNIVERSITÉ DU QUÉBEC EN ABITIBI-TÉMISCAMINGUE

PWCC's Annual General Meeting

INCREASING TREE PRODUCTIVITY IN HYBRID POPLAR PLANTATIONS DOES NOT LINEARLY TRANSLATE INTO GREATER SOIL ORGANIC CARBON SEQUESTRATION

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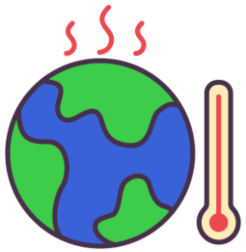
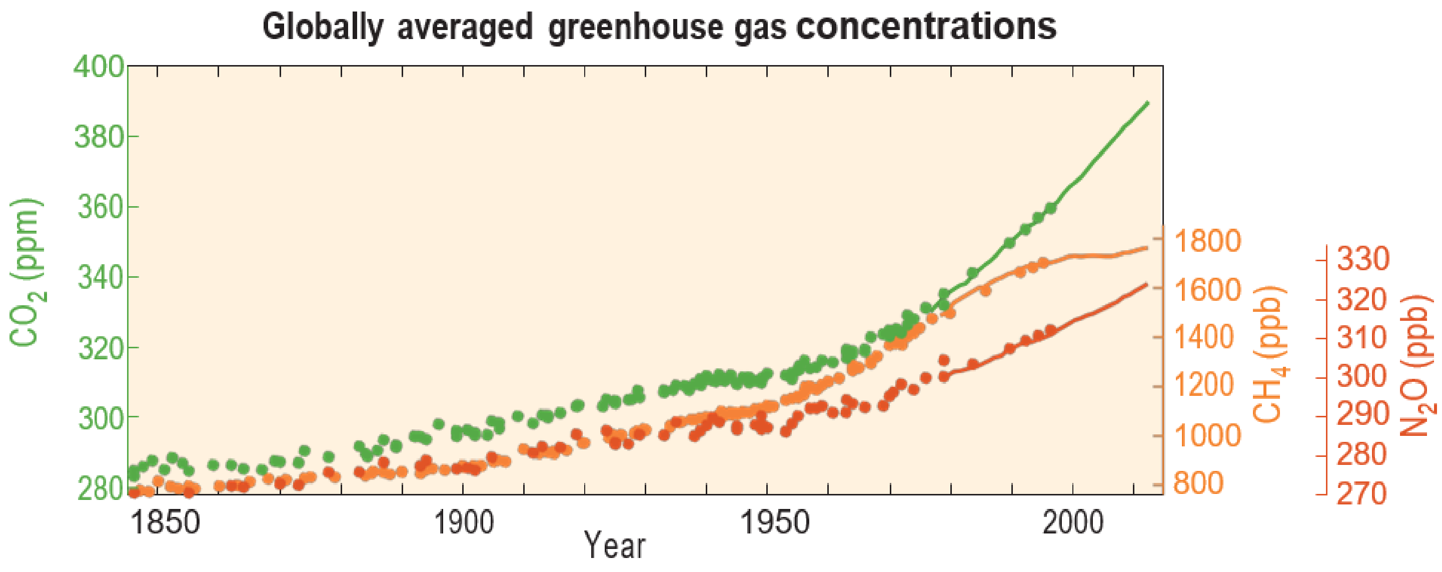
1-INTRODUCTION

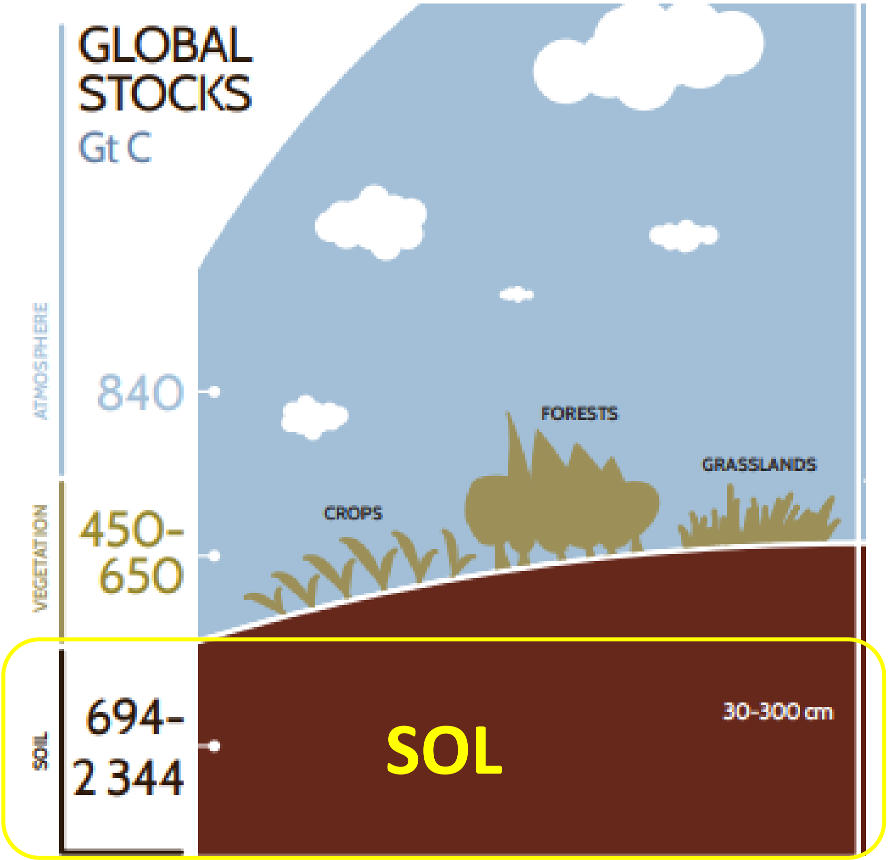


Climate change: one of the most significant challenges for humanity



(IPCC, 2014)

Soil: 2nd largest carbon (C) pool
3 times more C than vegetation



Global carbon Stocks (FAO, 2019)

1-INTRODUCTION

Solution: Fast-growing hybrid poplar plantations

Rapid biomass, litter accumulation and fine root turnover → More C inputs to the soil

C

Their roots can have faster respiration rate or be rapidly decomposed compared to those of slow-growing species → More C loss to the atmosphere

CO_2

Unclear relationship between tree productivity and soil C

(Block et al. 2006; Comas et al. 2002; Dewar & Cannell, 1992; Kane et al., 2005; Sartori et al., 2007)

1-INTRODUCTION

Objective 1: to determine the impact of hybrid poplar productivity on soil organic carbon (SOC) at different soil depth

H1 : the most productive poplar clones would store **more C** in the soil

1-INTRODUCTION

distance from trees may also have a significant effect on SOC

SOC stock was greater underneath versus away from the tree canopy for oak forest.
More litter inputs underneath the canopy

SOC stocks do not always differ with distance from trees

(Howlett et al., 2011, Oelbermann & Voroney, 2007; Peichl et al., 2006)

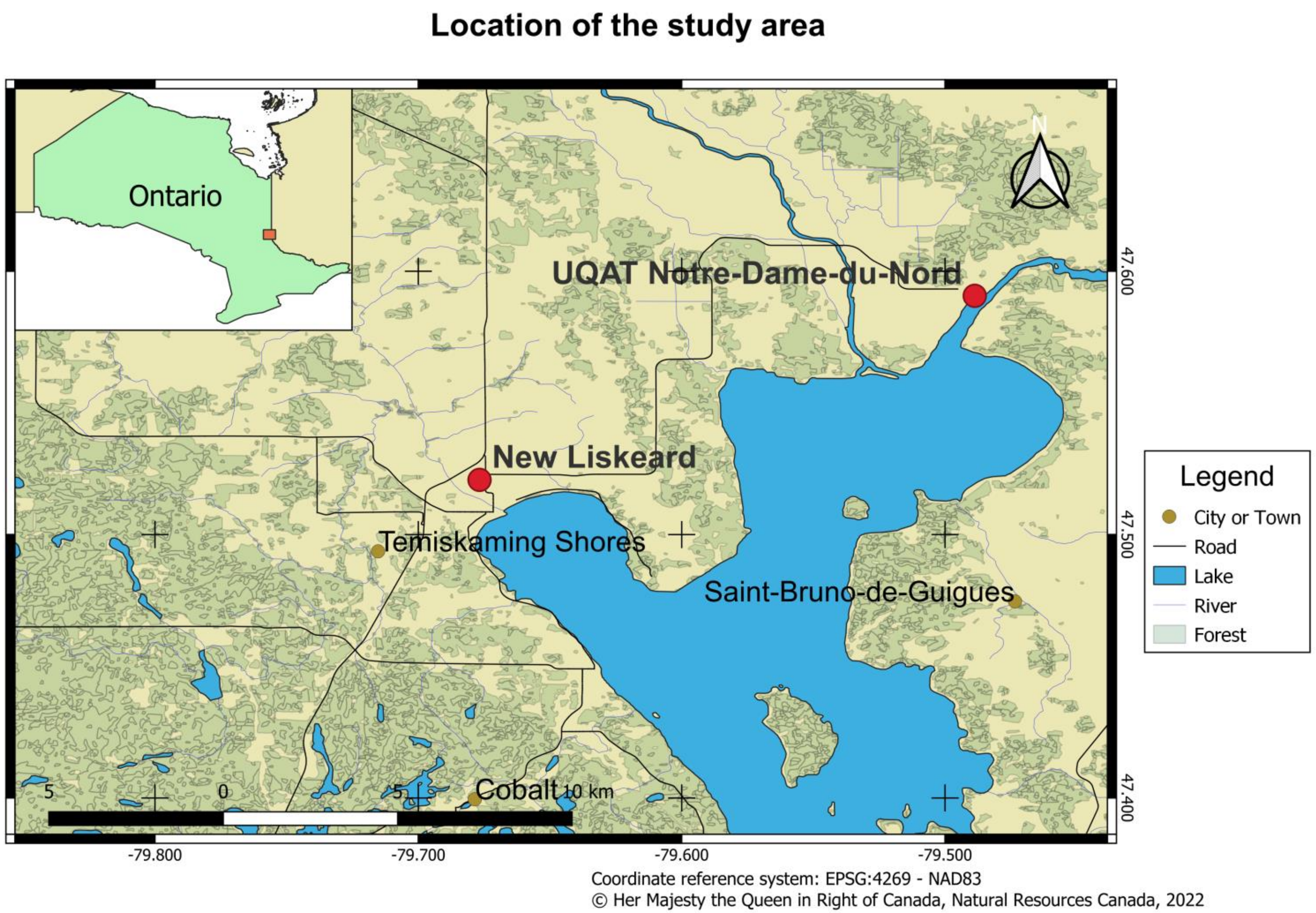
1-INTRODUCTION

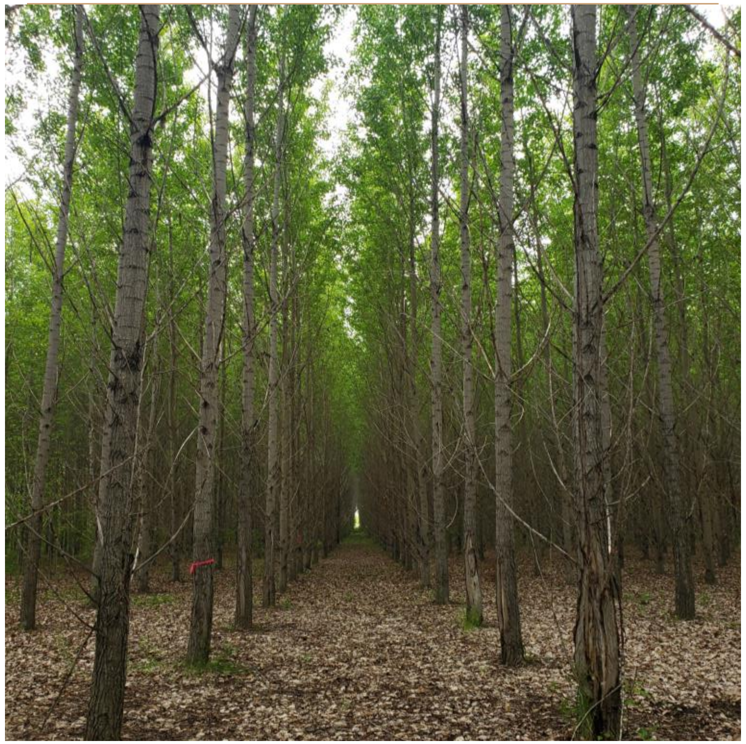
Objective 2: to determine the effect of distance from trees on SOC stocks.

H2 : SOC would **increase** with decreased sampling **distance from the stems**.

3-METHODS

Site description



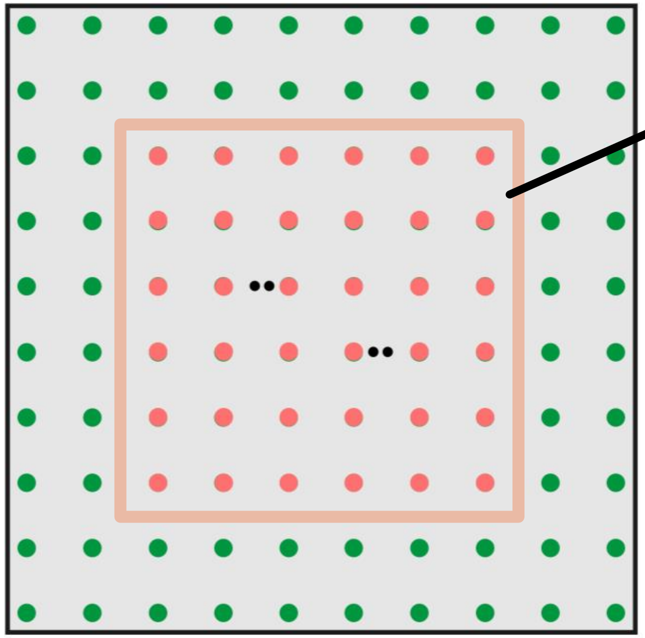


-Plantation of **14-year-old hybrid poplar**

-3 replicate blocks of monoclonal plots (10 rows x 10 trees)

3-METHODS

Tree measurements (summer 2021)



Monoclonal plot

Subplot of **6 rows*6 trees (36):**

-Diameter of breast height (DBH)

-Height of trees

Average annual growth rate **(**$m^3\ ha^{-1}\ year^{-1}$**)**

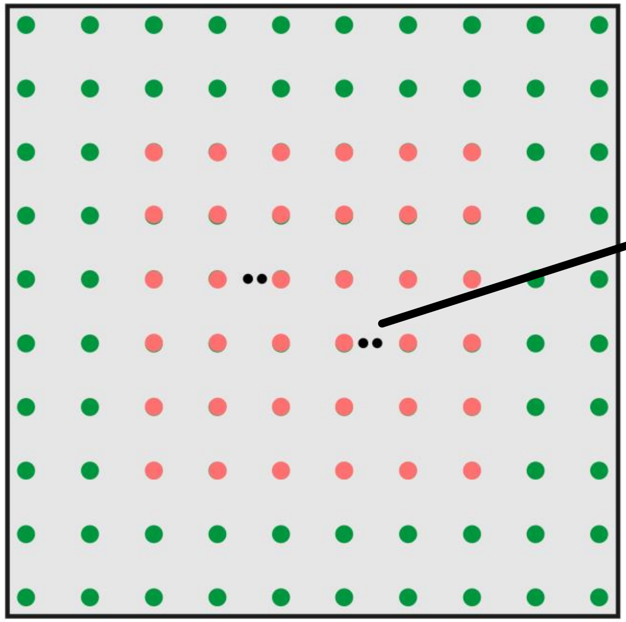
$$= \frac{Total\ V}{Subplot\ area * age}$$

5 selected clones according to their productivity :

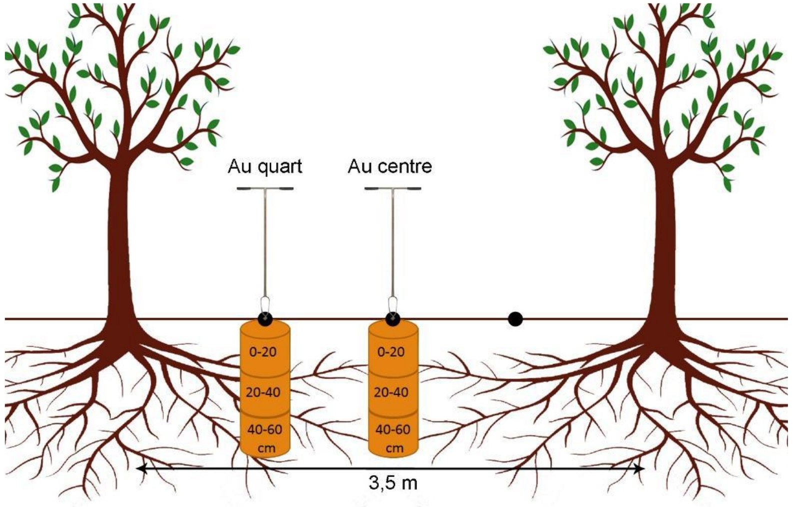
- **747210** (*P. balsamifera* x *P. trichocarpa*),
- **915005** (*P. maximowiczii* x *P. balsamifera*),
- **1079** *(Populus* x *jackii* (*P. balsamifera* x *P. deltoides*)),
- **915319** (*P. maximowiczii x P. balsamifera*) and
- **DN2** (*P. deltoides* x *P. nigra*).

3-METHODS

Soil sampling and carbon analysis



Monoclonal plot



Soil cores sampled at **two distances** (**87.5** and **175.0 cm**) from a stem and at **3 soil depths (0-20, 20-40 and 40-60 cm)**

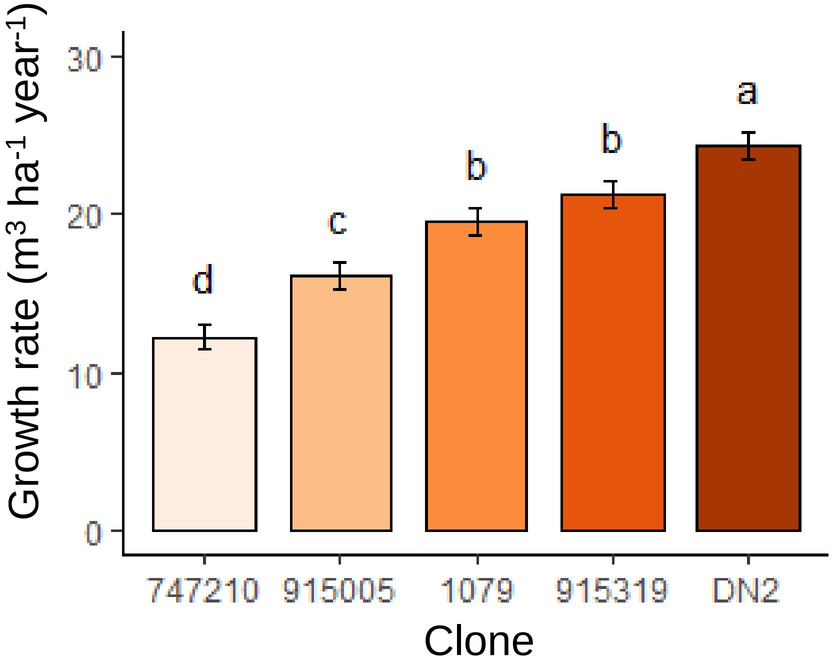
C Analysis by **dry combustion** in laboratory (CNS-1000)

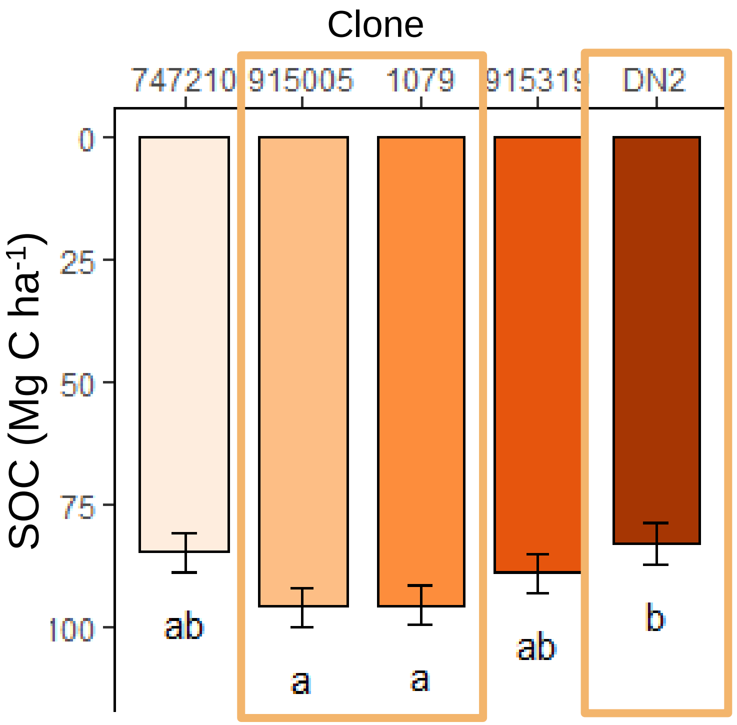
$$SOC\ stock = SOC\ content \times BD \times d \times 0.1$$

Statistical analysis: Linear mixed models and emmeans

4-RESULTS

Productivity and total SOC stock (0-60 cm)





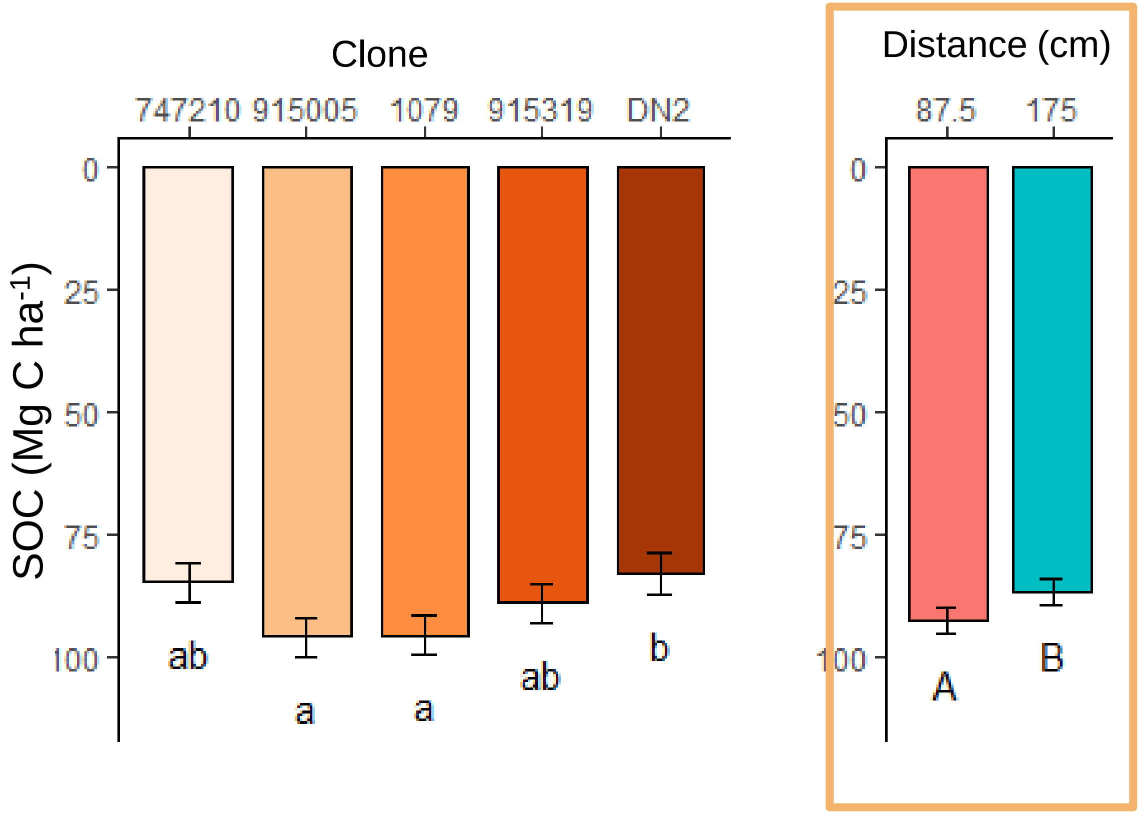
-the most productive clone (DN2) stored less SOC than the mid-productive clones 1079 and 915005

-the least productive clone (747210) stored less SOC than other clones, but the difference was not significant

=>**Non-linear relationship** between productivity and SOC stock

4-RESULTS

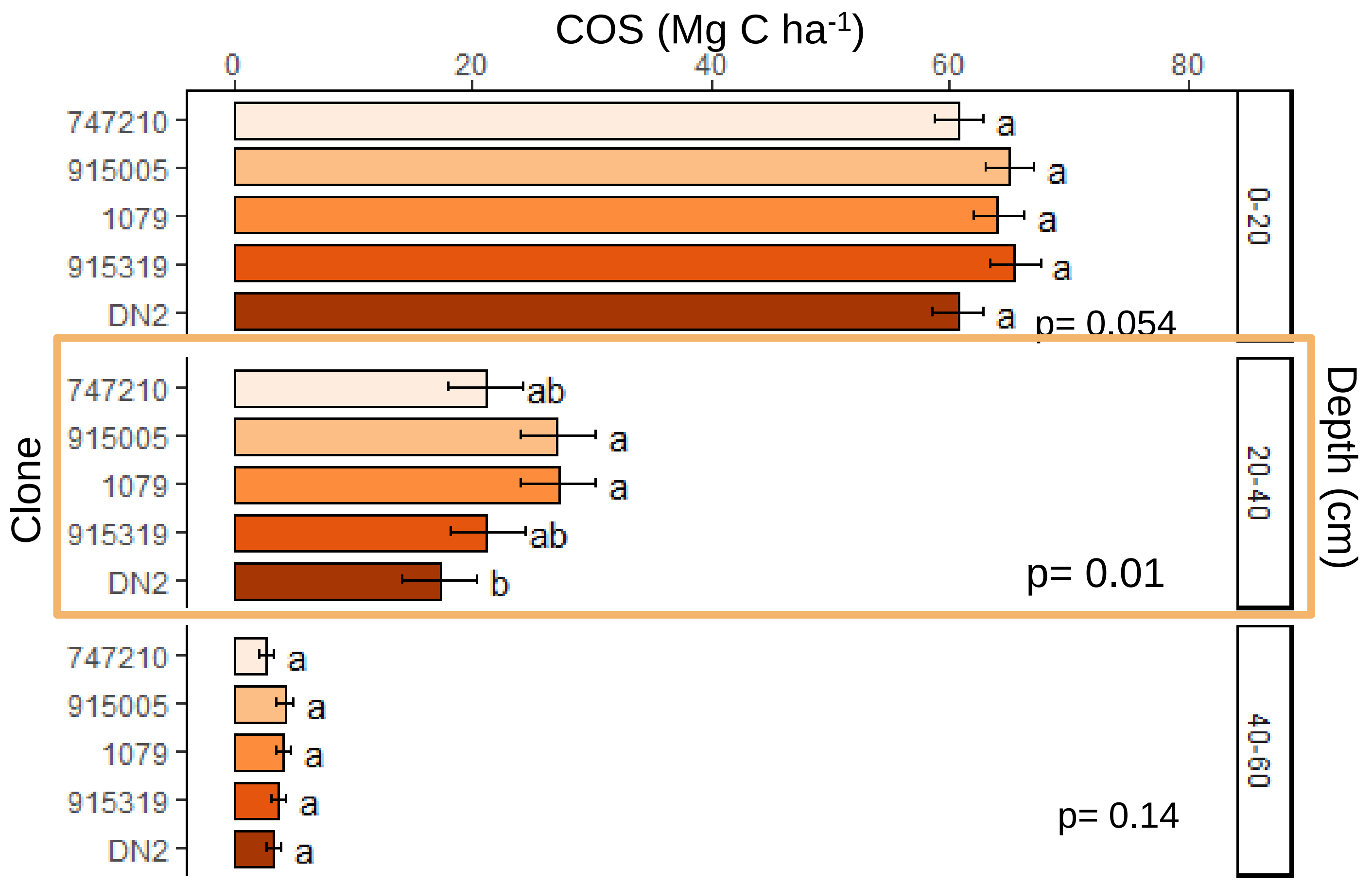
Distance effect



Total **SOC stocks increased** by **6 %** when the sampling distance was **closer to the stem**

4-RESULTS

SOC stock at each depth



-SOC stock was **greater within the first 20 cm layer** of the soil and decreased rapidly with increasing depths

-**Differences in SOC stock** between clones were **mostly observed at the 20-40 cm depth**

-At the 40-60 cm layer, SOC stocks were significantly low for all clones

4-RESULTS

C/N ratio and bulk density

Depth(cm)	Clone	C/N	Bulk density (g cm^{-3})
0-20	747210	11.32(±0.17) b	1.05(±0.02) a
	915005	11.61(±0.17) ab	1.00(±0.02) a
	1079	11.88(±0.17) a	1.00(±0.02) a
	915319	11.36(±0.17) b	1.05(±0.02) a
	DN2	11.66(±0.17) ab	1.01(±0.02) a
20-40	747210	10.06(±0.46) ab	1.22(±0.04) a
	915005	10.76(±0.46) a	1.22(±0.04) a
	1079	10.43(±0.46) ab	1.17(±0.04) a
	915319	9.61(±0.46) ab	1.25(±0.04) a
	DN2	9.46(±0.46) b	1.22(±0.04) a

- 0-20 cm: The **least productive clone** had lower soil C/N ratio than the mid-productive clone (1079)
- 20-40 cm: the **most productive clone** had lower soil C/N ratio than the mid-productive clone 915005

- No significant difference in soil bulk density between clones at all depths

4-DISCUSSIONS

Importance of productivity on SOC

Most productive clone (DN2) stored **less SOC**:

Inconsistent with our 1st hypothesis and other studies that predicted that increased aboveground productivity leads to increased soil carbon sequestration (Peichl et al., 2006; Weslien et al., 2009)

⇒ The **decomposition rate** of OM could be higher (lower soil C/N ratio) (Berg et al., 1998; Taylor et al., 1989; Yu et al., 2019)

⇒ It could supply more **labile and high-quality OM**

⇒ By the addition of this new labile C, **more priming effect** which stimulated the decomposition of **recent as well as stable organic carbon** (Cheng et al., 2014; Jansson & Hofmockel, 2020)

4-DISCUSSIONS

Importance of productivity on SOC

Least productive clone (747210) also stored **less SOC**:

⇒ Lower organic matter input in the topsoil or **higher decomposition rate** (low C/N ratio in the topsoil)
(Taylor et al., 1989; Yu et al., 2019)

⇒ The difference in SOC could be the result of a difference in **the quality of OM supplied** into the soil.

=> T**he quality** of the organic matter may be more essential than **the productivity** to promote soil C sequestration (Mueller et al., 2015).

4-DISCUSSIONS

Link between root and SOC

As the difference in SOC stocks between clones was mostly observed at **the 20-40 cm layer**

-Plant roots could be significant OM sources in deep soil (Rumpel and Kögel-Knabner, 2011)

Difference in SOC stock between clones could be **mainly due to roots**.

-For mid-productive clones that stored more SOC: roots more **resistant to decomposition** and **rich in recalcitrant compounds** (lignin) (de Boer et al., 2005; Zak et al., 2006).

-For the most productive clone (less SOC): it could promote **root exudation** leading **priming effect** (Dijkstra et al., 2006) or **promote fine roots** that have **higher respiration rate** than coarse roots (Desrochers et al., 2002).

=> There could be differences in **root traits between clones, l**eading to differences in SOC

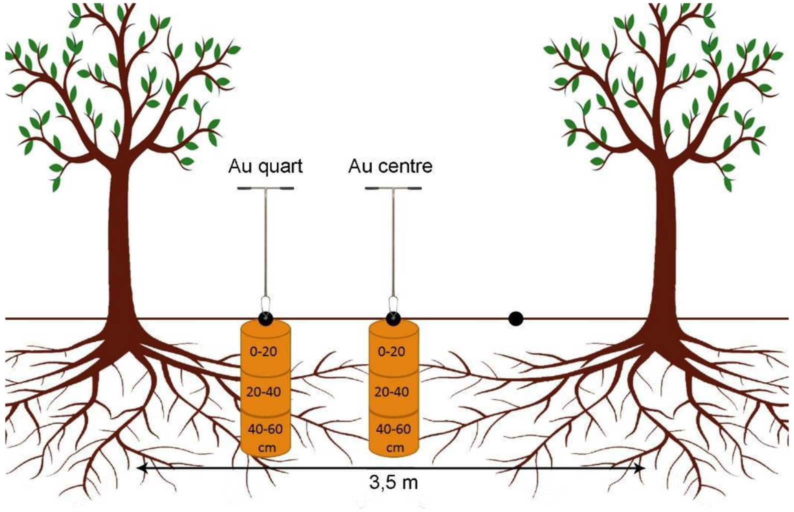
4-DISCUSSIONS

Link between root and SOC

SOC stocks increased when the sampling distance was closer to the stem**:**

-Consistent with **our 2nd hypothesis** and the study of Howlett et al. (2011) on oak forest due to **the tree canopy** that could contribute to litter inputs

- Also confirmed **the contribution of roots on SOC** since they are more abundant near the stems.



5-CONCLUSION

For fast-growing trees:

1. The relationship between tree productivity and SOC stock **was not linear.**
2. **The distance from trees** had a significant effect on SOC.
3. The mid-productive clones (**1079 and 915005**) stored more SOC than the most productive clone since they would promote **recalcitrant OM.**
4. **SOC sequestration** may be more dependent on **the quality of organic matter** than **on tree productivity**.
5. **Roots contribute significantly to soil C sequestration** since the difference in SOC stocks between clones was mostly observed in the 20-40 cm depth.

=> We will study the root traits to give us more answers. (chap 2 of the thesis)

“THANK YOU!”

ACKNOWLEDGEMENTS

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