Sensitivity of soil heterotrophic respiration to temperature: short term impacts.

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1. Introduction:

- Temperature is the most important driving factor of soil heterotrophic respiration and its impacts may be different according to the timescale.
- A good understanding of the process is still missing.
- Despite their considerable importance, crop soils have been less investigated so far.

2. Objectives:

- To bring new elements to get to a better understanding of short-term temperature impacts on respiration of crop soils.

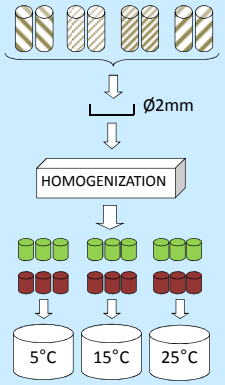
3. Material and Methods:

➢ Experimental site:

- Soil samples were taken in June and August at the Carbo-Europe site of Lonzée, Belgium.
- In this 12ha-field, 4 areas of 9m² each were weeded in March 2009 to provide bare areas for soil sampling.
- Soil characteristics:

Parameter	Value
Soil type (FAO)	Luvisol
Soil texture: Silt Sand Clay	 70% 5% 25%
Soil organic carbon content [kg/m²]	6.2
C:N ratio	9.40
Bulk density (0-30cm) [kg/m³]	1500
pH (H_2O)	7.9

➢ Soil sampling and subsample preparation:



2 auger samples (6cm Ø , 14cm height) were taken from each of the 4 bare areas delimited in the field.

The samples were sieved at 2mm and homogenized.

Both times, 2 sets (see table below) of 9 new samples (100g fresh soil) were prepared from the whole quantity of soil, put into 210 mL jars and slightly compacted.

3 jars of each set were placed into each incubator. Incubator temperatures set at 5, 15 and 25°C.

	June	August
Set # 1	Field moisture **Flux measurements**	Field moisture **Flux measurements**
Set # 2	Field moisture **Biomass measurements**	Higher soil moisture content **Flux measurements**

➢ Experimental protocol and measurements:

- Pre-incubation period: 5 days.
- Cycle 1: Temperature modified sequentially by 10°C-steps between 5 and 35°C, starting from the incubation temperature (see the example in *Fig. 1*). This temperature cycle lasted about 22h.
- Cycle 2: same as cycle 1, repeated two days later.
- Respiration flux measurements at each temperature step with a dynamic closed chamber system (IRGA : Gascard II, *Edinburgh Instruments Ltd*, UK).

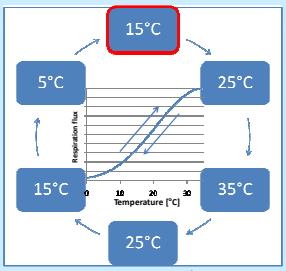


Fig. 1: The temperature cycle of incubator B.

- Between each measurement, ventilation of jars with outside air to prevent CO_2 from accumulating inside the jars.
- Microbial biomass measurements with the fumigation-extraction method
- Labile carbon analyses with the hot water extraction method

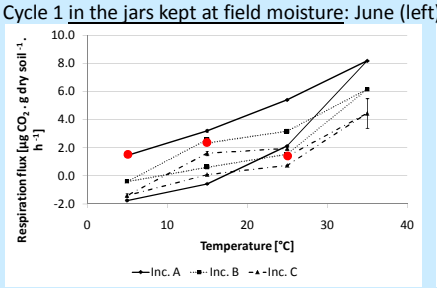
EXPERIMENTAL SET-UP:

- 3 incubators keeping the temperature constant between 5 and 35°C.
- A water-bath to warm up or cool down the jars inside the incubators.
- Continuous sample ventilation with water-saturated air in each incubator.
- Check of temperature evolution in the samples with thermocouples.
- Soil moisture content kept constant and adjusted every day if necessary.

Fig.2 : View of the 3 incubators.

4. Results:

➢ Cycle 1 in the jars kept at field moisture: June (left) and August (right):



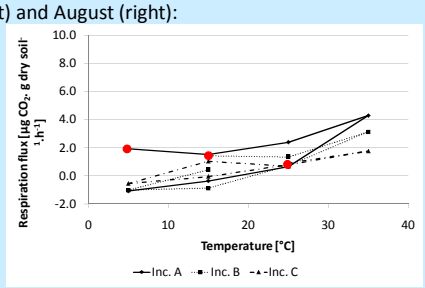


Fig. 3 a (left, June) and b (right, August): Evolution of soil respiration fluxes with temperature in the three incubators (pre-incubation temperatures: inc. A: 5°C, inc. B: 15°C, inc. C : 25°C).

➢ Pre-incubation period and initial fluxes:

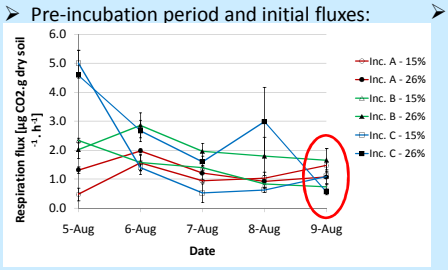


Fig. 4 : Evolution of soil respiration fluxes in the different incubators during the pre-incubation period in August. Field moisture = 15% weight; higher soil moisture = 26% weight.

➢ Comparison between soil moisture treatments (August):

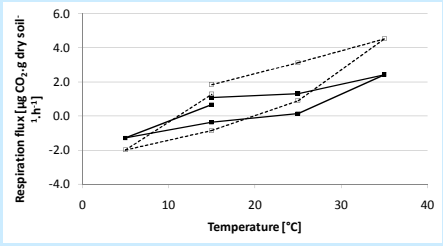


Fig. 5 : Evolution of soil respiration fluxes with temperature for both soil moisture treatments in August (full line: field moisture (15% weight); dotted line at 26% weight) in incubator B during cycle 2.

5. Main observations :

❑**Short term impact**:

❑Soil respiration increases clearly with temperature. The increase is larger in June (Fig. 3 a and b).

❑Clear and generalised hysteresis effect : larger fluxes in ascending temperature phases. Hysteresis larger at higher soil moisture contents.

❑Negative fluxes observed during cooling phases in all situations. No biological explanation (see below).

❑**Pre-incubation impact :**

❑ After 5 days, the fluxes appear hardly sensitive to incubation temperature and moisture treatement (red circle in Fig. 4 and red dots on Fig. 3 a and b), BUT :

❑ The short term response to temperature is clearly affected by the pre-incubation temperature : larger respiration increase observed in the coolest incubator (Fig. 3).

❑ No significant impact of incubation temperature or time on labile carbon and microbial biomass.

➔ **Negative fluxes : Hypotheses:**

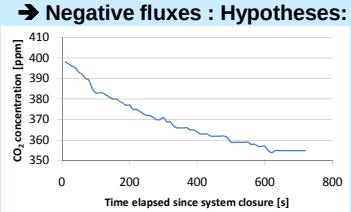


Fig. 6 : Drop of CO_2 concentration in a jar at 5°C once the system is closed.(complementary test).

- Henry's law: increase of CO_2 solubility in water with temperature decrease. Not enough to explain the magnitude of the negative fluxes.
- $CaCO_3$ equilibrium shifts in the soil: $CaCO_3$ could be formed or dissolved as temperature varies (but we lack some information about the $CaCO_3$ content in our soils).
- Any suggestion ?

6. Conclusions

- These results suggest that:
  - The impact of temperature is not the same at a daily and a hourly scale.
  - The response to temperature is different during heating and cooling phases.
- Physical processes could take over biological processes under certain conditions. We still lack a good understanding of the interactions between these two types of processes.

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