Carbon dioxide emissions from croplands in Niger

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Introduction

- The most important greenhouse gases emitted from agricultural sectors are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) which contribute respectively for 60, 15 and 5% to increase the global warming (IPCC, 2007)
- Niger has registered an increase in GHG emissions related to agricultural soils from 2008 to 2017 (CNEDD, 2020) but the current understanding of GHG emissions from agricultural practices has not been documented yet
- The main objective of this research is to quantify of GHG emissions under different agricultural practices in the Sahelian zone of Niger

Materials and Methods

Study sites:

- N'Dounga (13°24.354' N, 002°19.041' E) for field measurements
- Institute of Radio-Isotopes IRI (13°30.282' N, 002°05.111' E) with an experimental set up on fertilizers application for millet crop

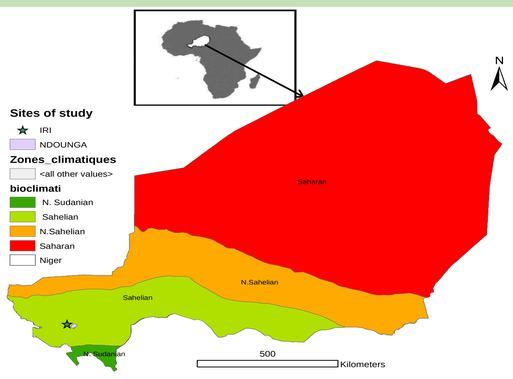


Fig. 1: Location of study sites

Carbon dioxide measurements:

Fig. 2: SEMACH-FG closed chamber systems

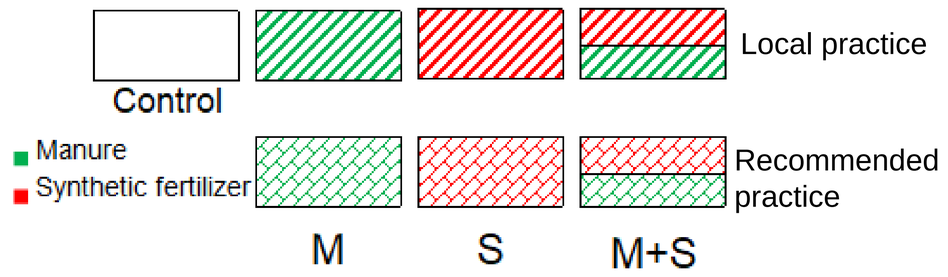
CO_2 fluxes calculation: $F_{CO2} = \frac{\Delta_{CO2} * Vch * Pch * 100}{R * (Tch + 273.15) * Ach}$

Where:
F_{CO2} = CO_2 flux (μ mol m^{-2} s^{-1})
Vch = Volume of chamber (m^3)
ΔCO_2 = change of CO_2 mixing ratio(ppmv/s)
Pch = Air pressure inside the chamber (mbar)
R = Universal gas constant (8.3145 J $mol^{-1}K^{-1}$)
Tch = Temperature inside the chamber (°C)
Ach = Base area of the chamber system (m^2)

Experimental design

Fertilizers experiment at IRI:

2 fertilizers (manure, synthetic fertilizer) and 2 application levels (farmers' practices/local and recommended):



1 site x 1 crop (millet) x 7 treatments x 5 replicates (blocks) = 35 plots

Fig. 4: Experimental site at IRI

Field measurements/N'Dounga site:

Croplands/Site N'Dounga

- **Highland (2 plots)**
  - **Millet included (3 collars)**
  - **Bare soil (3 collars)**
- **Lowland (2 plots)**
  - **Millet included (3 collars)**
  - **Bare soil (3 collars)**

Note: Measurements took place twice a month from July to September 2022

Preliminary results

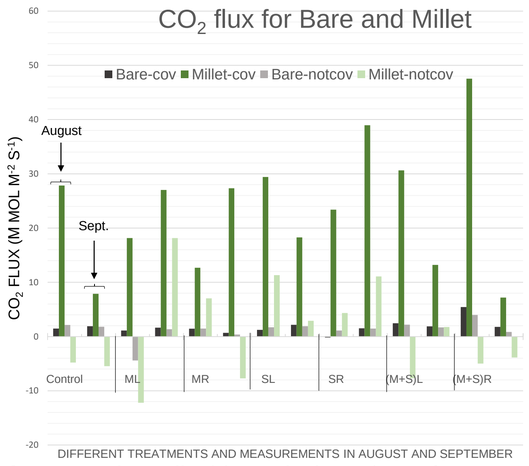


Fig. 4: Carbon dioxide emissions (μ mol CO_2 m^{-2} s^{-1}) from bare soils and millet included according to the treatments

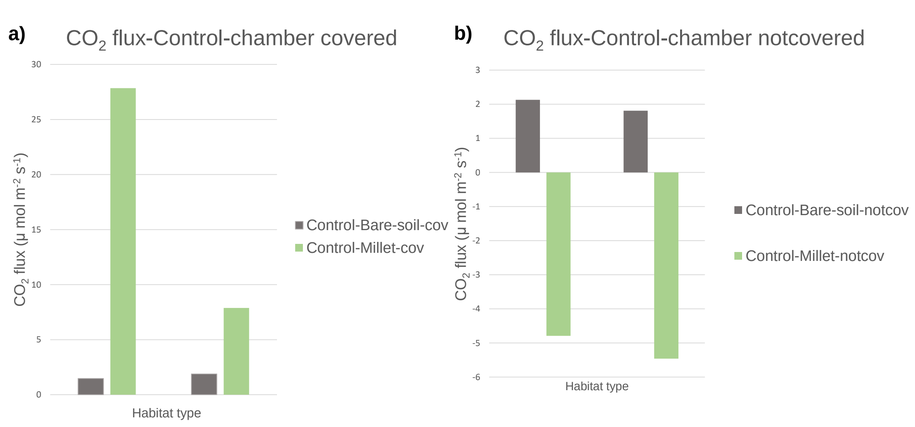


Fig. 5: CO_2 flux from bare soil and millet included in August and September **a)** chamber covered and **b)** chamber not covered

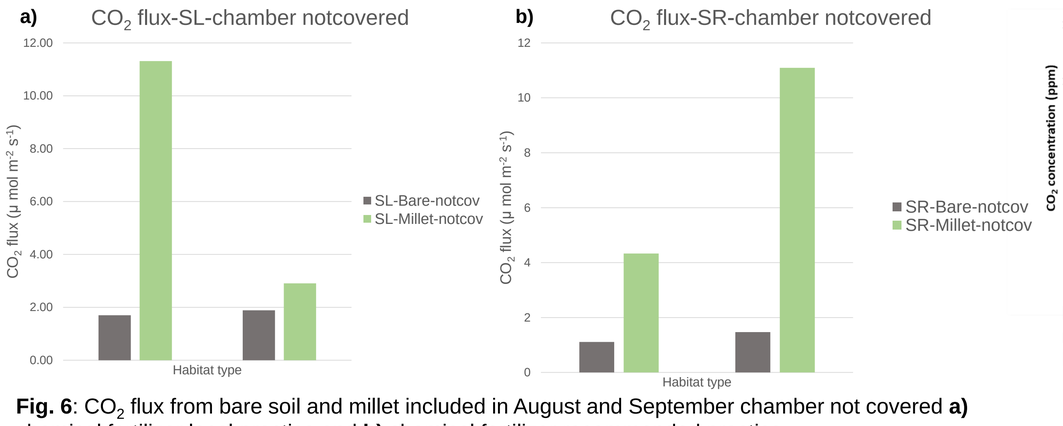


Fig. 6: CO_2 flux from bare soil and millet included in August and September chamber not covered **a)** chemical fertilizer local practice and **b)** chemical fertilizer recommended practice

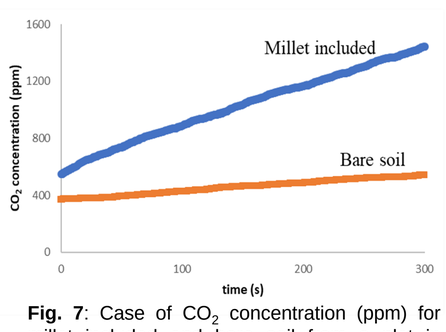


Fig. 7: Case of CO_2 concentration (ppm) for millet included and bare soil from a plot in N'Dounga

The highest emission rate was most likely in the month of August and the combination of manure and recommended synthetic fertilizer has shown higher carbon dioxide emission rate (Figure 4). With no treatment applied, when the chamber is covered, both bare and millet included act as sources while when the chamber is transparent (photosynthesis allowed), millet acts as sink (Fig. 5 a) and b)). But surprisingly in the case of synthetic fertilizer for both practices when the chamber is transparent, both bare and millet included act as sources (Fig. 6 a) and b))

In the same conditions, the carbon dioxide emission rate can be 3 to 4 times more important when the plant is included than for the bare soil (Fig.7). C. Oertel et *al.*, 2016 found similar values.

Conclusion

- Some key parameters impact on the carbon dioxide emissions: dark or transparent mode of the chamber, the time of measurements, climate conditions (air temperature, air pressure), soil characteristics (soil pH, humidity), stage of growth of the millet plant and the management practices (fertilizers used and period of use)
- Need to adapt the chamber height to the rapid growth of millet plant

References

- CNEDD (Conseil National pour l'Environnement et le Développement Durable), 2020, Inventaire National des Gaz à Effet de Serre, Secteur Agriculture et Elevage: Rapport définitif, Niger.
- Cornelius Oertel, Jôrg Matschullat, Kamal Zurba, Frank Zimmermann, Stefan Erasmi, 2016. Greenhouse gas emissions from soils- A review. Chimie der Erde 76 (2016) 327-352.
- IPCC (Intergovernmental Panel on Climate Change) Working Group I, 2007, Climate Change, The Physical Science Basis: Report, Canada.

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