Impact of Agroforestry on soil organic carbon sequestration in Madagascar using synchronic and diachronic approaches

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Introduction

Agroforestry (AF) is known to be an opportunity to sequester carbon in soil and biomass leading to climate change mitigation (Feliciano et al., 2018). It provides also multiple benefits for farmers (additional incomes and sustainable land management).

However, AF impacts on soil organic carbon (SOC) sequestration rate are rarely documented in tropical regions due to the lack of long-term field experiments.

This study is the first of its kind in Madagascar that aim to quantify:

(i) SOC storage in **AF** systems (fruit trees inside staple crop plot, (Photo 1)) in comparison to traditional farming practices (**TFP**, staple crop only (Photo 2)) and fallow land (**FL**, grass land (Photo 3)) for synchronic approach (2018), and;

(ii) SOC accumulation rate under AF after 4 years (2014 to 2018) for diachronic approach.

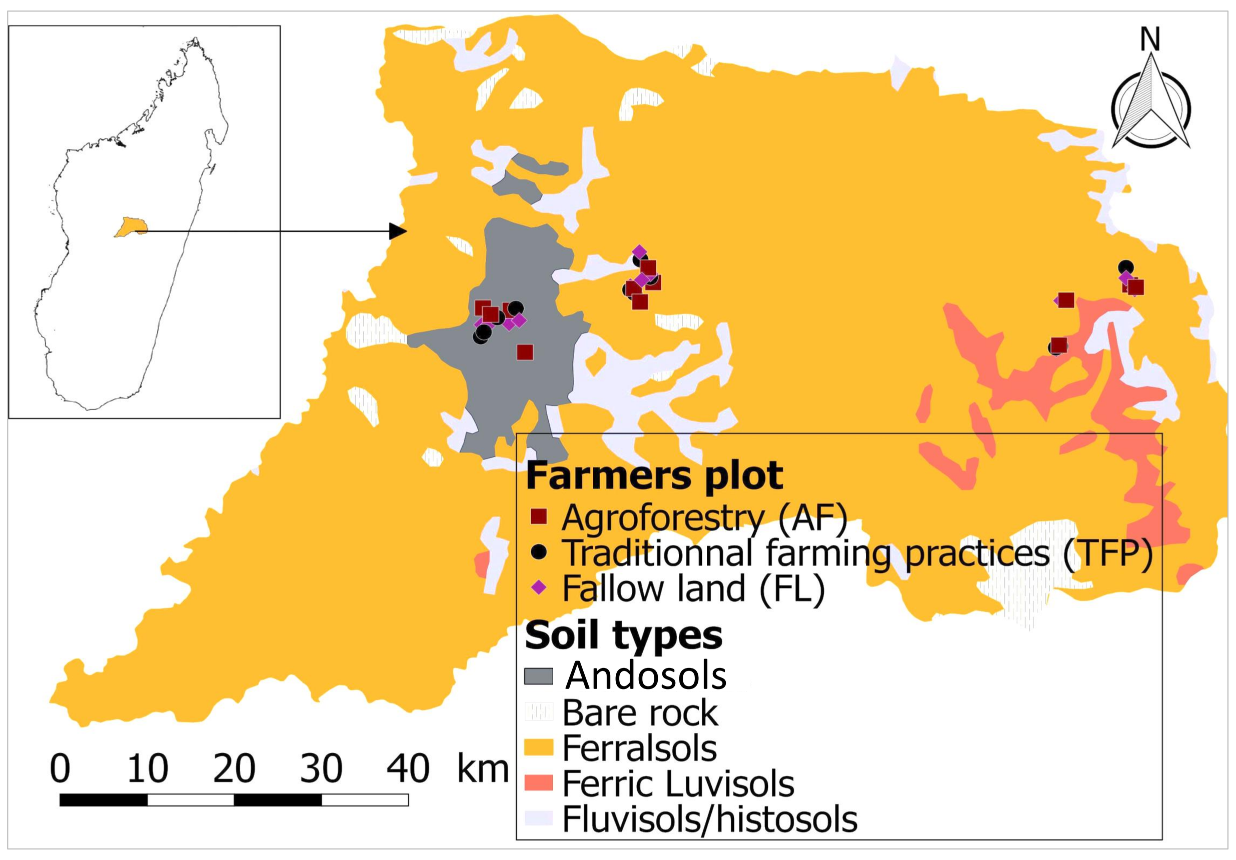

Fig 1: Location of studied plot in the Itasy Region

Photo 1: Agroforestry plot

Photo 2: Traditional farming practices plot

Photo 3: Fallow land plot

Material and Methods

- **The soil survey** was conducted in 2014 and 2018 over the Itasy Region, in the Central Highlands of Madagascar, region dominated by two soil types: ferralsols and andosols (Fig 1)
- **Soil sampling** by using steel cylinder (502.4 cm^3) was conducted at 3 soil depth (0-10, 10-20 and 20-30 cm) over 36 farmers' plots distributed according the studied practices (Table 1).
- **Bulk density** (BD) was calculated using the ratio of dry-weight soil and cylinder volume.
- **Soil carbon content** was estimated by using Mid-infrared spectroscopy (MIRS) analysis.
- **SOC stocks** were calculated in 30 cm depth using BD values, carbon content and percentage of coarse fraction for each depth.

Table 1: Description of studied practices

Practices	Description	n		
		Andosols	Ferralsols	Total
AF	Combination of annual crops (*rainfed rice, cassava, sweet potato, maize, beans and vegetables*) and fruit trees (*Coffea arabica, Citrus sp., Litchi chinensis, Mangifera indica, Persea americana*).	4	8	12
TFP	Rotation of rainfed rice, maize, beans and cassava. With a very low organic matter intake rate (< 5 tons. $ha^{-1}.yr^{-1}$)	4	8	12
FL	Uncultivated land that was abandoned by farmers due to soil infertility and low water retention. Dominated by *Aristida sp.*	4	8	12

Results and discussion

- **SOC stocks in AF was significantly higher** (109 $MgC.ha^{-1}$) than TFP (67 %) and FL (61%) (Fig 2).
- The diachronic method showed an average **SOC accumulation rate up to 3.0 $MgC.ha^{-1}.yr^{-1}$ for AF**.
- Accumulation rate in andosols is lower compared to ferralsols, due to SOC saturation effect (Fig 2).
- High value of SOC sequestration on AF was due to an important organic fertilization supply (12 $tons.ha^{-1}.yr^{-1}$ of manure) and trees density (500 feet ha^{-1}) feeding the soil biomass (Rakotovao et al., 2017).

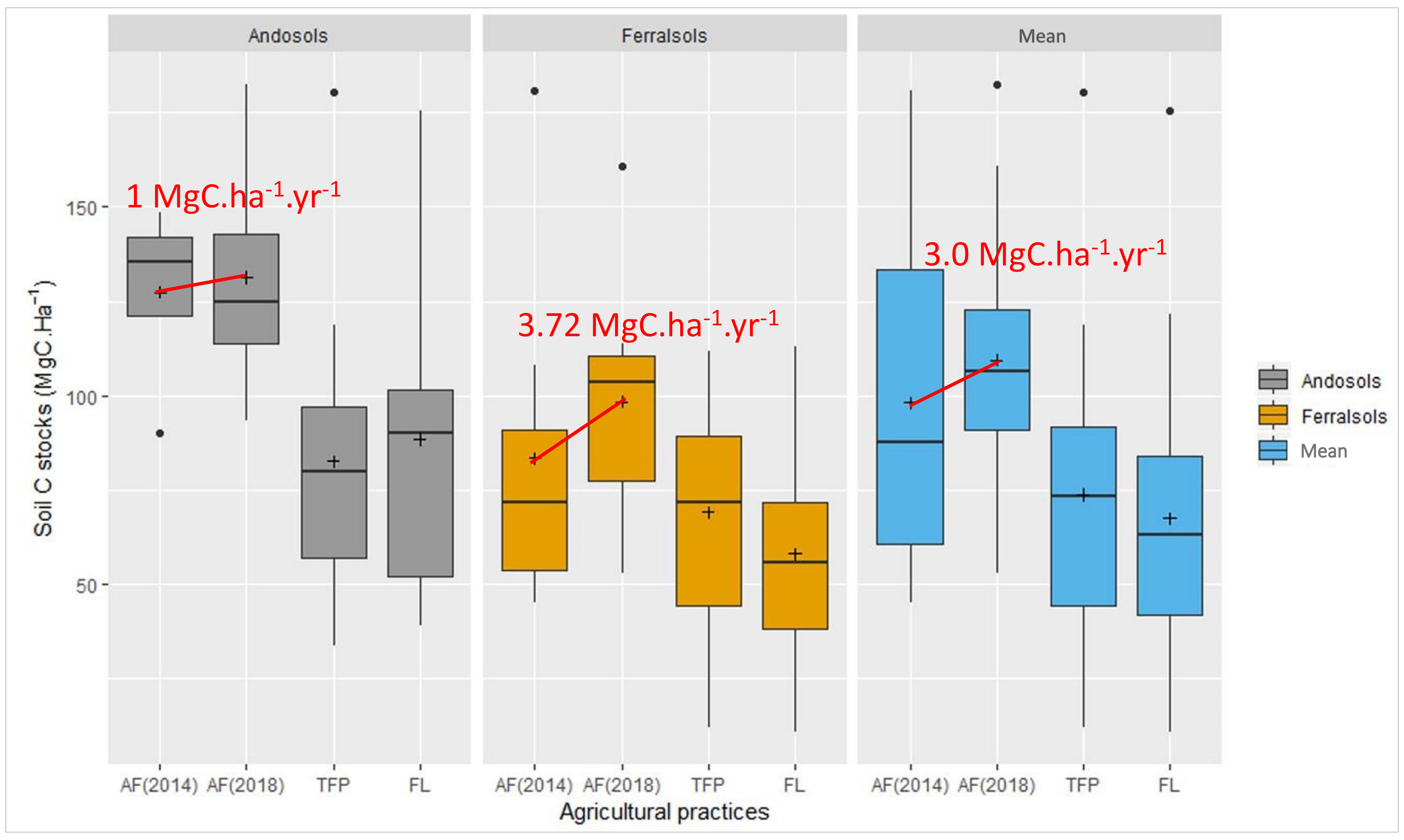

Fig 2: Soil carbon stocks of AF (2014 and 2018 year) , TFP and FL

Conclusion

This study confirmed the potential of AF to sequester organic carbon in tropical soils compared to traditional practices. It argues for a better consideration of such systems in food security and climate change initiatives at national or global scales. Therefore, it is recommended to continue such innovative work (diachronic approach in a farming environment) by multiplying the systems (tree density, traditional system) and precisely following technical itineraries (compost supply, etc.).

References

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