Influence of Coffee Agroforestry Systems on Soil Carbon Stock and Carbon Mineralisation: A Case Study in Northern Thailand

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Introductions

- Deforestation affects soil carbon stock due to the soil environment under the canopy and the root systems of each plant species determine soil carbon mineralisation process.
- In the upper north of Thailand, forest area has recently been converted to agricultural area in particular coffee plantation.

Fig 1 Deforestation
Pic source: Inhabitat.com

Objectives of this study

(i) assess soil carbon stock and carbon mineralisation in various coffee agroforestry systems

Materials and Methods

1. Location

- The experiment was conducted at Nhong Hoi Highland Agricultural Research Station in Chiang Mai province, Thailand (18°55'19.6"N 98°48'55.0"E)

Fig. 2 Location
Pic source: vectorstock.com

2. Treatment description

- This study included four land use types (Fig. 3):
  (1) Forest (comparing site),
  (2) Coffee monoculture,
  (3) Coffee grown with forest
  (4) Coffee grown with fruit trees

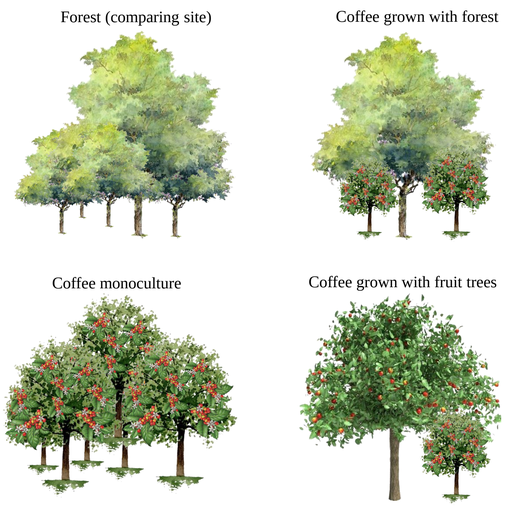

Fig. 3 Land use types

- To investigate soil carbon stock, nondestructive soil samples were taken at three different soil depths: 0–20cm, 20–40cm, and 40–60cm
- For carbon mineralisation study, destructive soil samples at topsoil layer (0 – 20 cm) were taken into the laboratory for the incubation experiment
- The soils were then sampled at day 1, 4, 7, 14, 21, 35 and 65 after incubation for dissolved organic carbon (DOC), microbial biomass carbon (MBC), and CO_2 emission analysis (Fig. 4).

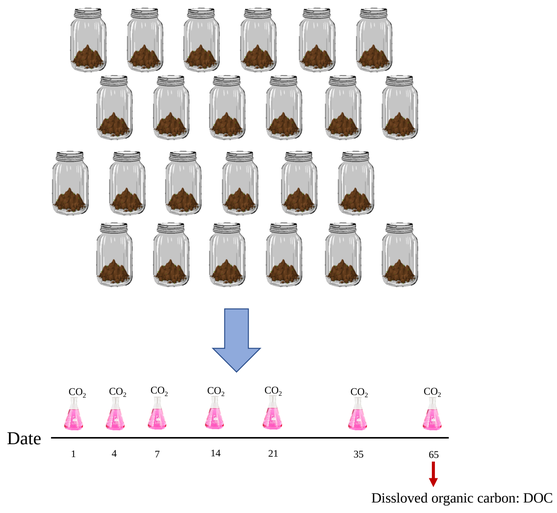

Fig. 4 Incubation and experiment for dissolved organic carbon (DOC) and CO_2 emission analysis.

- We conducted one-way analyses of variance (ANOVAs) followed by a least significant difference (LSD) test ($p \leq 0.05$) to detect any significant differences in variables across different land uses.

Results

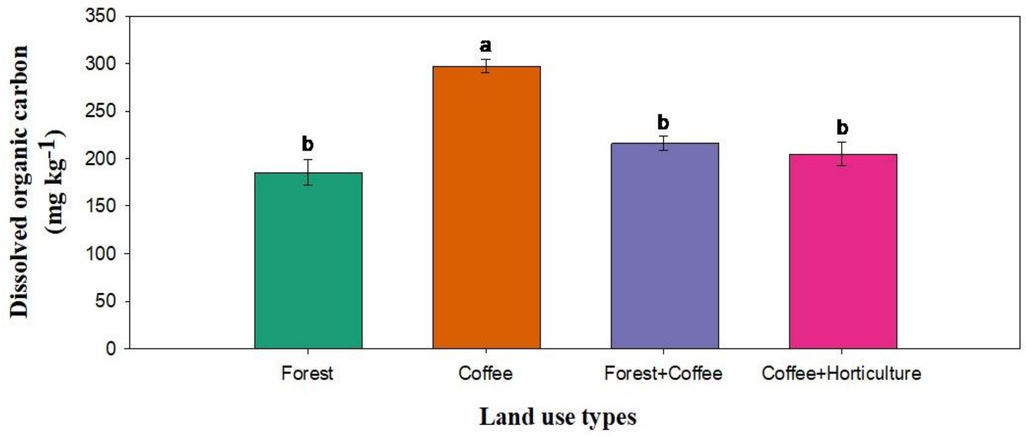

Fig. 5 Soil dissolved organic carbon in different land use types

Note: The error bars represent the standard error of the mean (n=3). Different lowercase letters within each panel indicate significant differences between land-use types in each soil layer. These differences were determined using the least significant difference (LSD) test at a significance level of P≤0.05.

- Dissolved organic carbon (DOC), forest soil was found to be considerably less than coffee monocrop ($p < 0.05$), , the coffee monoculture has founded DOC values of 297.57 mg kg^{-1}. Coffee grown with fruit trees had the lowest DOC 204.78 (mg kg^{-1}).

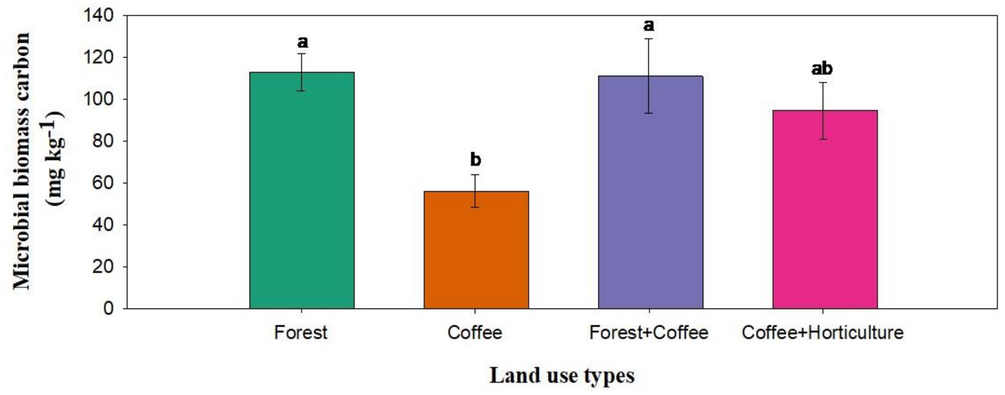

Fig. 6 Soil microbial biomass carbon in different land use types

Note: The error bars represent the standard error of the mean (n=3). Different lowercase letters within each panel indicate significant differences between land-use types in each soil layer.

- Microbial biomass carbon (MBC), forest soil was found to be considerably higher than coffee monocrop and coffee grown with fruit trees ($p < 0.05$), with MBC values of 94.59 mg kg^{-1}. Coffee monoculture had the lowest MBC (56.18 mg kg^{-1}).

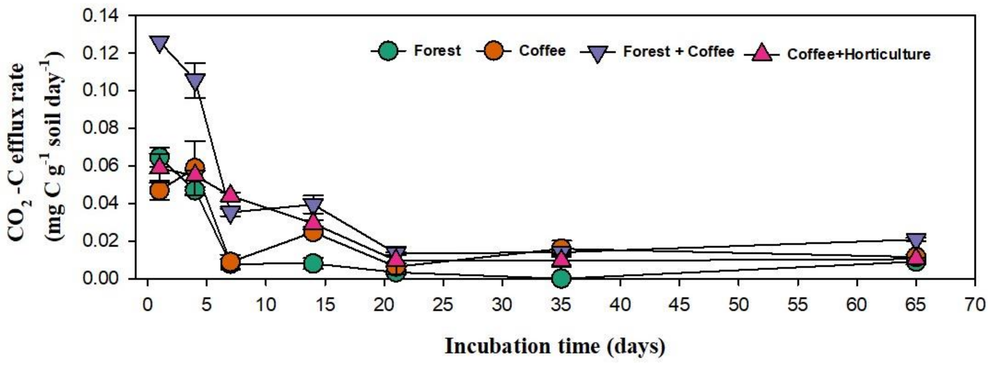

Fig. 7 CO_2 –C efflux rate in different land use types

Note: The error bars represent the standard error of the mean (n=3).

- The coffee with fruit trees at topsoil layer (0–20 cm) had the lowest soil carbon emission, followed by coffee monoculture and the forest, while the soil from the coffee grown with the forest had the highest soil carbon emission.

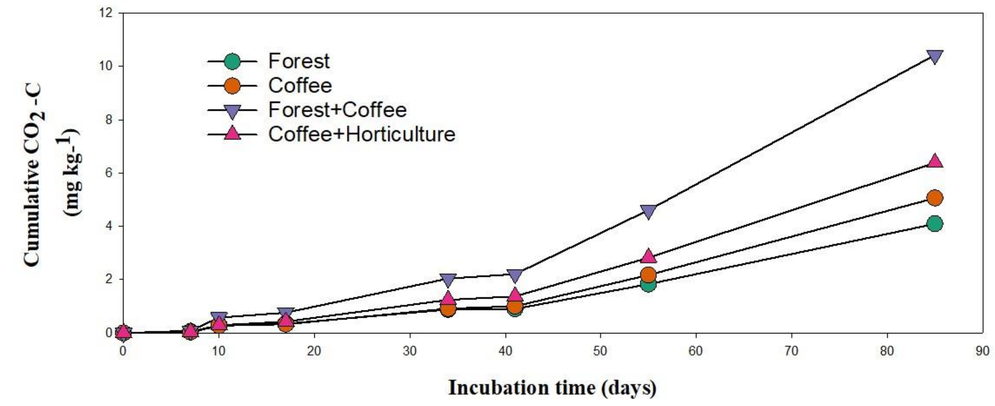

Fig. 8 Cumulative CO_2 emission from various land use types

- Cumulative CO_2 emission showed that coffee grown with forest contributed the highest CO_2 emission (10.3 mg kg^{-1}) while forest had the lowest value of CO_2 emission (4 mg kg^{-1}).

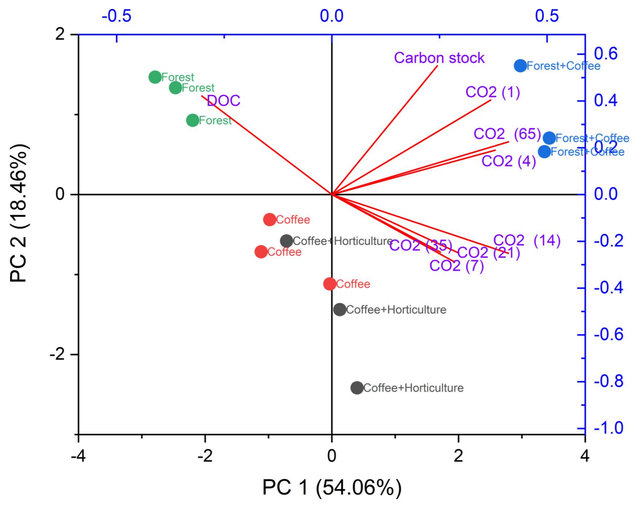

Fig. 9 Principal components analysis (PCA) to identify the relationships among the soil carbon stock and Dissolved organic carbon and Carbon stock each day after incubation.

- Carbon stock in soils was determined by land use types. PCA showed the CO_2 emission in soil decreased with the increase of dissolved organic carbon (DOC). Contrasted to the carbon stock in soil significantly increased with the increased of CO_2 emission in soil.

Conclusion

- Combined coffee and forest cultivation can boost biodiversity more than coffee monoculture.
- Coffee cultivation in association with forests or perennial fruit trees can be options for sustainable Arabica coffee cultivation in Northern Thailand.

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