國立臺灣大學

INTEGRATING BRANCH- AND SOIL- LEVEL FLUX MEASUREMENTS TO INVESTIGATE CARBON EXCHANGE DYNAMICS IN TEA PLANTATIONS

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RESULT

- January (dormancy)

Stable canopy (LAI = 2.18) and low soil temperature (15.1C) keep the ecosystem a carbon sink

- February (pruning shock)

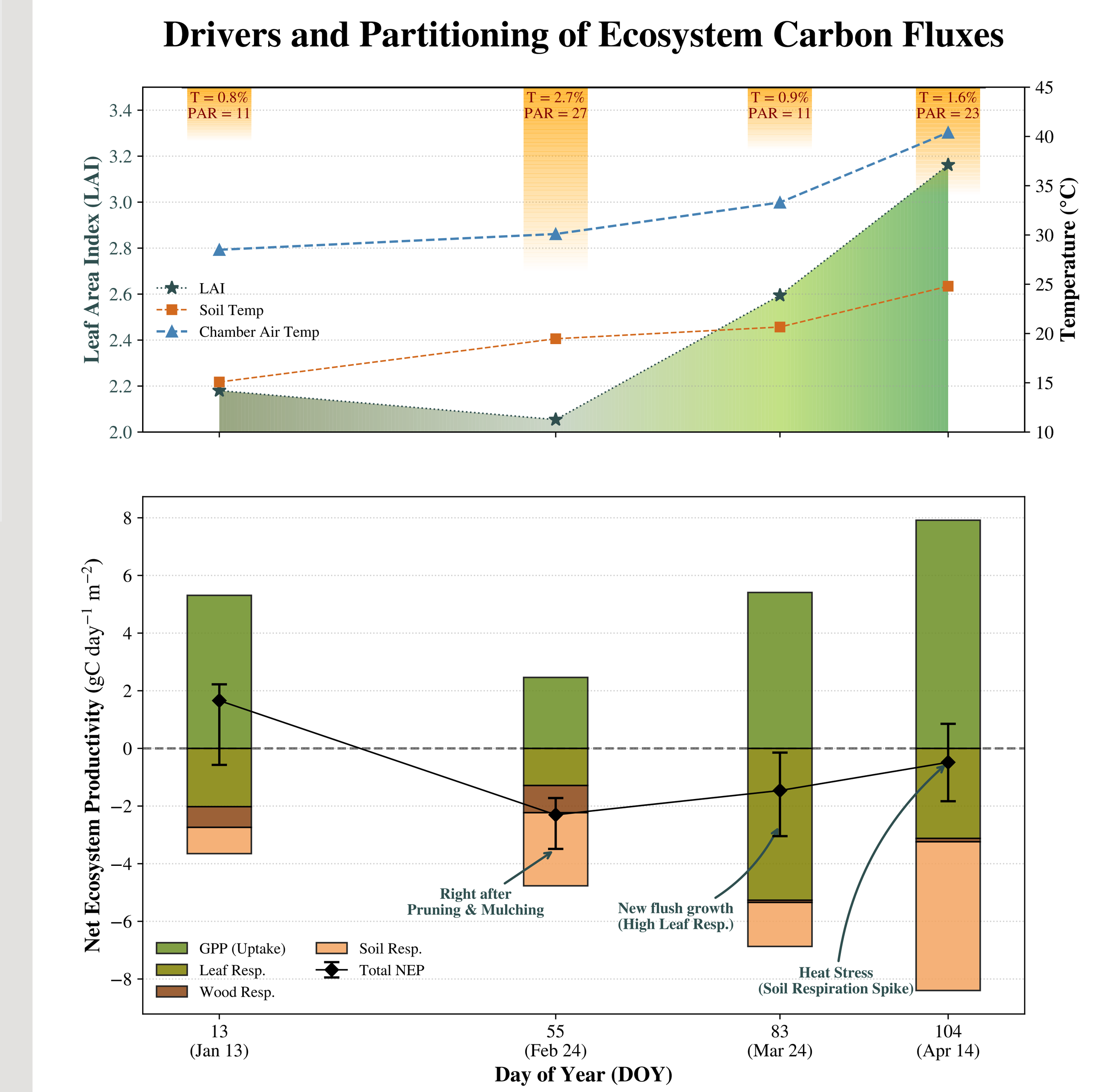
Canopy loss drops GPP, while exposed soil and warmer temperature trigger a surge in soil respiration, making the system a strong carbon source (NEP = -2.30)

- March (new flush)

GPP rebounds as LAI recovers, but high metabolic demand of young leaves acuses massive leaf respiration, offsetting assimilation gains

- April (heat stress)

Mature canopy maximizes GPP (7.91). However, extreme heat triggers an exponential spike in soil respiration (-5.15), overwhelming assimilation and keeping the system a small carbon source



INTRODUCTION

Anthropogenic greenhouse gas emissions continue to drive global climate change, highlighting the importance of terrestrial ecosystems in regulating atmospheric carbon. While vegetation acts as a major carbon sink through photosynthetic uptake and biomass accumulation, carbon sequestration research has predominantly focused on forest ecosystems. In contrast, agricultural systems—especially perennial crops—remain comparatively underrepresented despite their extensive land coverage and long-term management.

Tea plantations (*Camellia sinensis*) are perennial agroecosystems composed of long-lived woody shrubs with repeated harvest cycles and sustained biomass, suggesting a potentially significant but poorly constrained role in terrestrial carbon cycling. In Taiwan, tea is a major commercial crop occupying extensive agricultural land, yet quantitative assessments of plant–soil carbon exchange processes in tea systems remain limited. To better understand carbon exchange processes in tea plantations, this study applies a dual-approach integrating plant- and soil-level greenhouse gas measurements in a managed tea garden in Taiwan.

METHODS

Field measurements were conducted from January to April 2026. Branch-level photosynthesis and respiration were monitored using branch cuvettes, and gas exchange rates were extrapolated to the plant level using allometric relationships.

Concurrently, soil carbon dioxide (CO2) fluxes were measured using static chamber techniques to characterize soil–atmosphere carbon exchange, with fluxes further extrapolated to the garden scale. Measurements were repeated monthly under fair-weather conditions and supported by laboratory gas chromatography analysis. Ancillary environmental variables and management activities were recorded to support flux interpretation.

agricultural practices

November 15th
Winter harvest

--- 01/13

February 14th
Pruning

--- 02/24

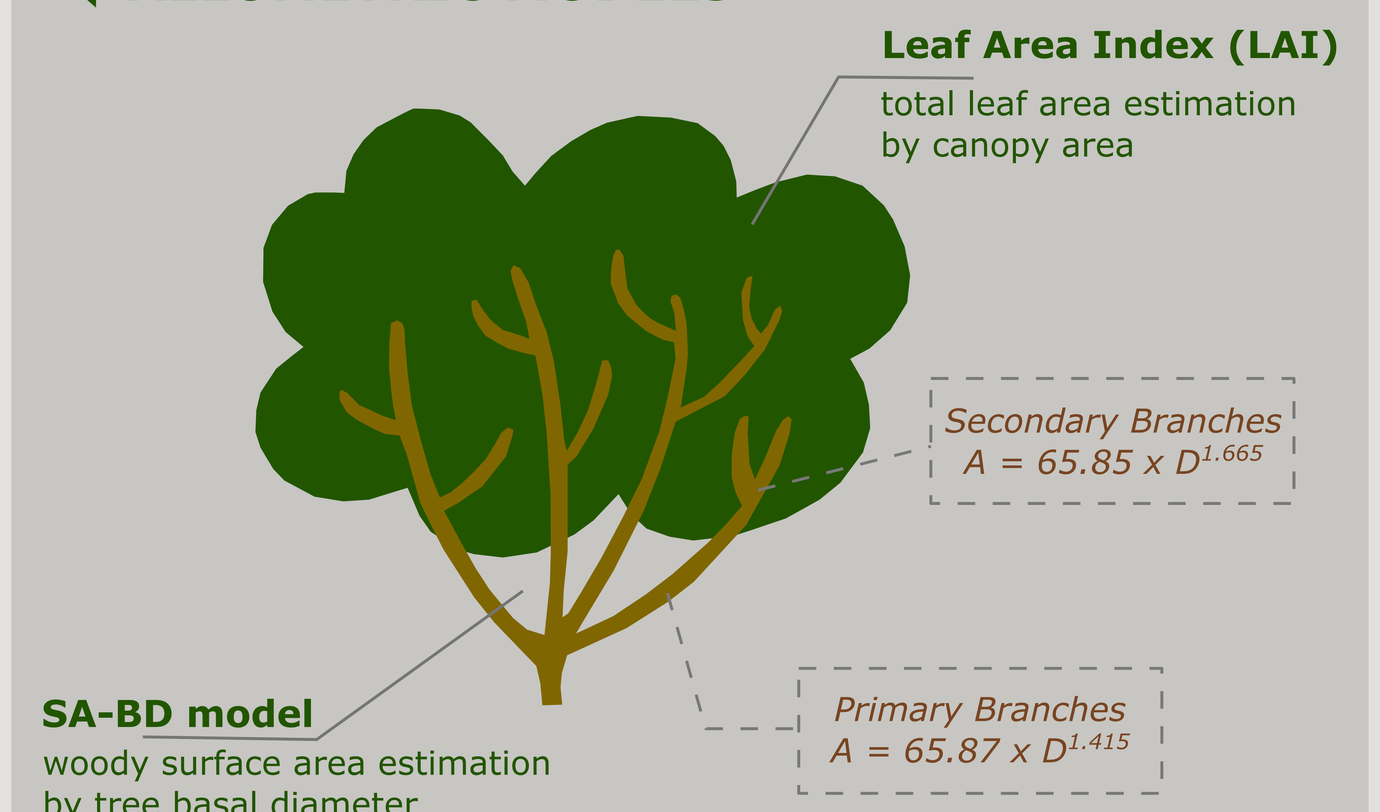
April 3rd
Spring harvest

--- 03/24

April 9th
Skiffing

--- 04/14

ALLOMETRIC MODELS



- January 13th: Baseline

recorded winter dormancy state with intact mature canopy

- February 24th: Post Pruning

measured immediately following winter pruning and soil mulching operations, from which the canopy was severely reduced

- March 24th: Spring Flush

captured the peak emergence of young spring shoots (new flush)

- April 14th: Mature Canopy & Heat Stress

Canopy fully expanded, recorded under extreme microclimate conditions (high temperature)

SOIL CHAMBERS

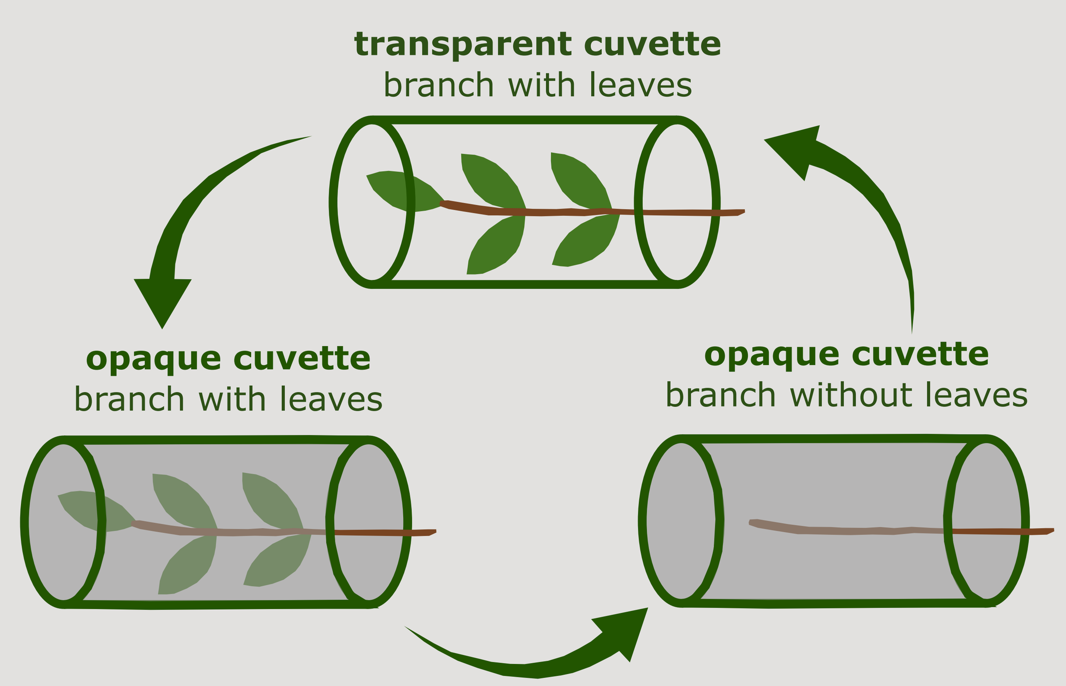
Opaque acrylic soil chambers wrapped in aluminum foil were used to exclude sunlight and prevent photosynthetic interference, ensuring that measured fluxes represented soil respiration only.

Each chamber measured 20 × 20 × 25 cm and consisted of a removable cover and a fixed anchor inserted 8 cm into the soil. Four replicate chambers were installed in the field for statistical replication, with each chamber deployed for 1 hour during measurement.

BRANCH CUVETTES

Acrylic cylindrical branch cuvettes were used for branch gas exchange measurements. Transparent cuvettes were applied for photosynthetic measurements, whereas opaque cuvettes wrapped in aluminum foil were used for respiration measurements to exclude light.

Each cuvette measured 20 cm in diameter and 40 cm in length. The same branch was sequentially measured for whole-branch photosynthesis, whole-branch respiration, and woody tissue respiration. This sequential design enabled flux partitioning among branch organs and provided input for subsequent geometric upscaling to the tree level. Each measurement was conducted over 10 minutes.



CONCLUSION

Overall, this study provides an integrated, field-based assessment of carbon exchange dynamics in a managed tea plantation by explicitly linking plant- and soil-level gas fluxes with seasonal progression and agricultural practices. By aligning greenhouse gas measurements with farming activities, the results offer insight into how management and phenological stages jointly regulate carbon exchange in perennial agroecosystems. The findings contribute to reducing current uncertainties surrounding the role of tea plantations in terrestrial carbon cycling and provide a scientific basis for future evaluations of carbon management and climate mitigation potential in perennial agricultural systems.

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