

Process of carbohydrate transferring and carbon budget in *Phyllostachys edulis* forests
(モウソウチク林における炭水化物の移動過程と炭素収支)

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Abstract

Phyllostachys edulis (Carrière) J. Houz. (*P. edulis*) is a special taller grass species. Individuals (ramets), connected to the belowground (rhizome and root) system, cause carbon (C) transfers between mature bamboos, young bamboos, and bamboo shoots.

In this series of studies, [Chapter 2] initial findings indicated that newly developed bamboos received C and rebuilt their photosystems when the first cold wave hits in a year due to the short-term shortages of C. Further, mature bamboos are very likely to provide carbohydrates to bamboo shoots. The hypothesis is formulated as a kind of nursing behaviours in *P. edulis*. To strengthen the hypothesis, I obtained further evidence by using ^{13}C pulse labelling *in situ*.

[Chapter 3] Before operating the ^{13}C pulse labelling, the main source of C provided by the photosynthetic type of developing bamboos should be clarified. Otherwise, it would affect the explanation for the results of ^{13}C pulse labelling. C_3 photosynthesis is performed in mature bamboo leaves at the autotrophic stage. Results demonstrated that the main C source was from the C_3 leaves of mature bamboos by natural bulk ^{13}C values in organs and ^{13}C pulse labelling in culms (giant grass stems), although the C_4 photosynthetic pathway was found in the skin of developing culms at the heterotrophic stage during the fast-growing periods (FGP) in previous studies. This case also revealed the evolution of plants in biosynthetic and metabolic pathways has no solidified classification in space, the photosynthetic chamber of cells, even in time, the stage of growth.

Following this, [Chapter 4] after obtaining two ^{13}C enriched mature bamboos *in situ*, samples (including leaves, branches, culms, rhizomes, roots, bamboo shoots, sheath leaves) were continually collected during a year. Then, C transfer from mature leaves to belowground systems and from belowground systems to sheath leaves of bamboo shoots was revealed by ^{13}C pulse labelling. Integrating results of *LR* of bulk organs and ^{13}C of respiration in a mature culm into a compartmental model of ^{13}C budget approach, I estimated the daily dynamic of ^{13}C partitioning in up to 15 days after ^{13}C pulse labelling. A high proportion of total assimilated ^{13}C was consumed for respiration (74.6%). Not much immobile ^{13}C remained in leaf, branch, culm, and individual belowground were 4.2%, 2.3%, 1.7%, and 0.7%, respectively, in labelled mature bamboo after the ^{13}C pulse labelling 15 days. The amount of total assimilated ^{13}C exported from individual mature bamboo to other belowground systems was 16.5%.

Results quantified that mature bamboo transported assimilated ^{13}C to belowground systems in autumn.

Furthermore, [Chapter 5] I separated carbon compounds and measured their excess ^{13}C to clarify the intentionality of carbon sink and source of different organs during seasons. The allocated amount of ^{13}C transferred from leaves and branches to culms between autumn and winter. The culm is the main C stock pool gradient that transferred C stocks to other sinks via rhizome systems. Further, I expanded the EDNOR-PCF-NPR model (based on Chapter 2) with biomass investigation to a seasonal carbon budget equilibrium approach for quantifying the seasonal dynamics of carbon allocation and flux in a *P. edulis* stand. The output of the seasonal carbon budget equilibrium model estimated that the gross production by photosynthesis (in leaves, green skin of branches and culms) was $31.6 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$. Leaves, branches, culms, and sheaths consumed photosynthetic products $2.4, 1.5, 6.3, 0.4 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$, respectively, via respiration. The litterfalls of leaves, branches, culms, and sheaths were $2.0, 0.2, 1.3, 1.2 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$. The respiration of the O horizon, mineral soil with organic matters (heterotrophic), and belowground systems (autotrophic) were $3.3, 6.2, \text{ and } 4.0 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$, respectively. Further, the carbon sinks in leaves, branches, culms, sheaths, belowground were $0.01, 0.1, 1.6, \text{ and } 0.6 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$, separately. And the details of the seasonal C dynamics were also estimated in Chapter 5. Gross production, aboveground net primary production (ANPP), belowground net primary production (BNPP), and respiration were high in summer and low in winter mainly depending on temperature.

In conclusion [Chapter 6], I then acknowledged the labelled ^{13}C , which was provided by mature bamboos, was stocked last autumn *in situ*, and supplied to roots and rhizomes in winter, to new leaves and branches of mature bamboo themselves and sheath leaves attached bamboo shoots in spring. This series of studies not only revealed that C was indeed transferred to young bamboos when they were needed but also integrated ^{13}C pulse labelling and mass-balance based carbon budget equilibrium approaches to elaborate the C allocation of individuals and the C cycling of stand levels in *P. edulis*.