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# Phytolith carbon sequestration in bamboos of different ecotypes: a case study in China

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**Abstract** Occlusion of carbon (C) within phytoliths (PhytOC) is becoming one of the most promising terrestrial C sequestration mechanisms. This study explored the production of PhytOC within 35 bamboo species belonging to three ecotypes using methods of microwave digestion. The aim of this study is to explore the present and potential C sequestration rate within phytoliths of bamboo species from three ecotypes. PhytOC content in bamboos of three ecotypes ranges from 0.07 % to 0.42 %. The mean PhytOC production flux decreases as: clustered bamboo (0.050 ± 0.016 t $CO_2$ $ha^{-1}$ $a^{-1}$) ≈ mixed bamboo (0.049 ± 0.016 t $CO_2$ $ha^{-1}$ $a^{-1}$) > scattered bamboo (0.038 ± 0.020 t $CO_2$ $ha^{-1}$ $a^{-1}$). The phytolith carbon sequestration in Chinese bamboo is estimated to be 0.293 ± 0.127 Tg (1 Tg = $10^{12}$ g) $CO_2$ $a^{-1}$; approximately 75 %, 3 %, and 22 % of which is contributed from scattered, mixed and clustered bamboo, respectively. Taking the PhytOC production flux of 0.18 ± 0.12 t $CO_2$ $ha^{-1}$ $a^{-1}$ and current annual area increasing rate of 3 %, global bamboo phytoliths would sequester 11.9 ± 7.9 Tg $CO_2$ $a^{-1}$ by 2050. Consequently, bamboo forests have significant potential to mitigate the increasing concentration of atmospheric $CO_2$ by maximizing PhytOC production flux and expanding bamboos.

**Keywords** Bamboo · Carbon sequestration · Ecotypes · Phytolith · PhytOC

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## 1 Introduction

Global climate change is one of the adverse effects of the increasing concentration of atmospheric greenhouse gas [1–3]. At present, the global concentration of atmospheric $CO_2$ has reached about 391 parts per million by volume [4] and the rate of increase is expected to be significant in the future due to the growing anthropogenic and natural emissions of $CO_2$, such as emissions from transportation, industry, electrical generation and building operations [1]. Removing atmospheric C and sequestrating it in the terrestrial biosphere is considered to be an effective way of reducing levels of atmospheric $CO_2$ [5–8].

The occlusion of carbon within phytoliths is one of the most promising mechanisms of biotic carbon sequestration [7, 8]. PhytOC is deposited within plants tissues (mainly in leaves) and released into the soil after plant decomposition [9–11]. PhytOC is a relatively stable form of C and has been demonstrated to represent up to 82 % of soil carbon in some sediments after 2000 years because of its strong ability to resist decomposition [10, 12–14].

Grasses and herbaceous plants such as bamboo, sugarcane, silvergrass and bulrush have been demonstrated to have considerable capacities to sequestrate $CO_2$ during the formation of phytoliths [2, 3, 7, 8, 11, 15]. The PhytOC production fluxes in economic bamboo [11], sugarcane

[15], wheat [16] and millet [17] have been reported to be 0.7, 0.36, 0.246 and 0.03 t $CO_2$ $ha^{-1}$ $a^{-1}$, respectively. These results suggest that bamboo has a larger potential of phytolith carbon sequestraion than other plant species.

Forest ecosystems sequester up to 80 % of total above-ground and 40 % of below-ground C of the earth, thus playing an important role in the global C balance [18–21]. Relative to other forests such as Chinese fir and Masson pine [22], bamboo forests have a stronger ability to sequester carbon because of their faster growth rate and easier propagation and regeneration [11, 23]. Bamboo forests are mainly distributed in the subtropics and tropics of South and Southeast Asia (particularly in China), Africa, and Latin America [6, 24] with a global area of $22 \times 10^6$ ha, accounting for about 1 % of the total area of the world's forests [22, 25]. Although the area of world's forests has decreased drastically, the bamboo forest area has increased at an annual rate of 3 % [25].

The area of bamboo in China is approximately $7.2 \times 10^6$ ha and is increasing progressively [6, 22]. During the past 30 years in China, afforestation and reforestation of bamboo and other forests have been successful in mitigating the ever increasing atmospheric $CO_2$ concentration by capturing it in living biomass [26, 27]. Although Parr et al. [11] had reported the phytolith carbon sequestration of bamboo, their study was focused on too limited bamboo species (10 species) and the factors of bamboo ecotype differences were not taken into full consideration. This study investigated the rates of phytolith production and phytolith carbon sequestration in 35 bamboo species of three different ecotypes in China. The purposes of this study are to examine the present and potential phytolith carbon sequestration rate of bamboo and offer references for the regulation of atmospheric $CO_2$ through phytolith C sequestration.

## 2 Materials and methods

### 2.1 Collection of bamboo leaves and soils

Based on morphological characteristics of underground stem, bamboos are usually divided into three ecotypes including clustered, scattered and mixed bamboos [20, 22, 28]. Clustered, scattered and mixed bamboos are originally distributed in tropical, subtropical, and relatively low temperature areas of the world, respectively [20, 22, 28]. The 35 dominant bamboo species of three ecotypes were sampled from a bamboo garden at Zhejiang Agricultural and Forestry University (30°15′N, 119°43′E), Lin'an, Zhejiang, China. The bamboo garden was built in 2000 and most of its bamboo species originate from southern China and Japan. Lin'an has a subtropical monsoonal climate. The frost-free period lasts up to 234 days, with an average of 1,400 mm rainfall annually, and the area has an annual average temperature of 16 °C. The soil of the site is acidic with a mean pH of 5.47. The contents of soil organic matter and total $SiO_2$ were 2.61 % and 57.81 %, respectively. The available Si content was 195.49 mg $kg^{-1}$.

The accumulation of Si is known to be greater in mature plant organs than in other organs [29–31]; we thus selected mature bamboo leaves (two year old) to ensure the maximum accumulation of Si. The mixing leaves from up to down of 35 bamboo species (three replicates) were sampled with a special sickle. Each bamboo sample made up about 300 g of composite mature leaf litters. Samples were rinsed with ultrapure water three times, oven-dried at 75 °C for 48 h, and cut into small pieces for chemical analysis.

Surface soil samples were collected near the base of bamboo, air-dried and divided into two subsamples. One subsample was passed through 20 mesh sieve and used to analyze soil pH. The other subsample was passed through 100 mesh sieve after removing root residua, and used to analyze contents of SOM, total $SiO_2$ and available Si [32].

### 2.2 Analysis of Si, phytoliths and PhytOC

After ashing and Li-metaborate fusion, samples were dissolved in dilute nitric acid and analyzed by spectrophotometry for Si content [32]. The bamboo phytoliths were extracted using a microwave digestion procedure [33]. Possible extraneous organic material of phytoliths was examined and removed with 0.8 mol $L^{-1}$ potassium dichromate [2, 3, 11, 34]. The cleaned phytolith samples were oven-dried at 70 °C for 24 h in a centrifuge tube, and weighed to obtain the content of phytoliths. All phytolith samples were checked with an optical microscope (Olympus CX31, Japan) to ensure that all possible extraneous organic material was removed [35]. The phytoliths were then treated with 4 mol $L^{-1}$ hydrogen fluoride (HF) at 45 °C for 60 min to dissolve phytolith-Si [36]. The organic C content within phytoliths after HF treatment was determined by the potassium dichromate method [32]. The PhytOC determination was checked with standard samples of GBW07405. The precision was better than 7 %.

### 2.3 Estimation of PhytOC production

The PhytOC production flux of bamboo leaf litter can be estimated from the PhytOC content of biomass and ANPP of leaf litter as

$$\text{PhytOC production flux} = \text{PhytOC content} \times 44/12 \times \text{ANPP of leaf litter}, \quad (1)$$

where PhytOC production flux is PhytOC production amount of bamboo leaf litter per area per year (kg $CO_2$

$ha^{-1}$ $a^{-1}$), PhytOC content is the PhytOC content in bamboo leaf litter biomass (wt%), and ANPP of leaf litter is aboveground net primary productivity of bamboo leaf litter (kg $ha^{-1}$ $a^{-1}$).

PhytOC production rate of bamboo leaf litter can be estimated from data of PhytOC flux and bamboo area as

$$\text{PhytOC production rate} = \text{PhytOC production flux} \times \text{area}, \qquad (2)$$

where PhytOC production rate is total PhytOC production amount in bamboo leaf litter per year (kg $CO_2$ $a^{-1}$), PhytOC production flux is estimated from Eq. (1), area is the area of bamboo (ha) [7].

Student's *t*-test and Excel and SPSS software were employed in the statistical analysis of all data.

## 3 Results

The dry weight of $SiO_2$, phytolith and PhytOC contents among the 35 bamboo species were 5.41 %–17.62 %, 3.47 %–16.28 % and 0.07 %–0.42 %, respectively (Table 1). However, the average contents of $SiO_2$ (9.22 %–13.35 %), phytoliths (7.69 %–11.09 %) and PhytOC (0.17 %–0.21 %) in leaf litter decreased in the following order: clustered $\approx$ mixed > scattered bamboo.

A significant correlation existed between the content of $SiO_2$ and phytoliths within the 35 bamboo species ($R^2 = 0.89$, $P < 0.01$) (Fig. 1). Phytolith content in leaf litter and PhytOC content in phytoliths were non-significant ($R^2 = 0.0255$, $P > 0.05$) (Fig. 2a). The correlation between PhytOC content in leaf litter and phytolith content of biomass was significant ($R^2 = 0.4588$, $P < 0.01$) (Fig. 2b). A significant correlation ($R^2 = 0.3442$, $P < 0.05$) (Fig. 2c) existed between PhytOC content in leaf litter and PhytOC content in phytoliths.

## 4 Discussion

### 4.1 Mechanisms of carbon sequestration within phytoliths of bamboo

The significantly possitive correlation among contents of $SiO_2$ and phytoliths in leaf litter of 35 different bamboo species ($R^2 = 0.89$, $P < 0.01$) (Fig. 1) demonstrate that the decreasing trend of phytolith contents in leaf litter (clustered $\approx$ mixed > scattered bamboo) (Table 1) can be attributed to different absorption capacities of Si in three ecotypes of bamboos. Ding et al. [37] and Parr et al. [11] demonstrated that the abilities of Si absorption varied among bamboo species possibility due to their different growth characteristics and habits, with stronger Si accumulation capacities in clustered and mixed bamboo than in scattered bamboo [11, 37] (Table 1). However, the exact mechanism and controlling factors of Si uptake difference among different bamboo species and ecotypes require further study.

In previous studies, many researchers found that dry weight of PhytOC in sugarcane, economic bamboo species, wheat and millet had no correlation with silica content [11, 15–17]. Moreover, they reported that the amount of C sequestered in plants mainly depended on the plant's C sequestration capacity during the formation of phytoliths rather than the actual silica taken up by plants. However, the results of this study are quite different. The significant correlations between the PhytOC content in leaf litter and phytolith content ($R^2 = 0.4588$, $P < 0.01$) (Fig. 2b) and between the PhytOC content in leaf litter and PhytOC content in phytoliths ($R^2 = 0.3442$, $P < 0.05$) (Fig. 2c) in this study indicate that the final production of PhytOC depends not only on the efficiency of phytolith carbon sequestration, but also on the actual phytolith production rate during plant growth. Thus, all possible measures that can improve the Si content of plants and the capacity of C occlusion in the phytoliths could be taken to increase the content of PhytOC in leaf litter. The applications of Si fertilizers [38–41] and Si-rich organic mulches [42, 43] have been shown to play an important role in enhancing the Si content and PhytOC accumulation during plant growth. In addition, applying fertilizers to increase the ANPP of bamboo may also increase the PhytOC production flux. Besides the increasing of PhytOC production flux, the PhytOC production rate can also be improved through the expanding distribution area of bamboo.

### 4.2 The phytolith carbon sequestration in Chinese bamboos

The leaf litter production flux in clustered, mixed and scattered bamboo in China is reported to be 5.59–7.04 t $ha^{-1}$ $a^{-1}$, 3.77–8.14 t $ha^{-1}$ $a^{-1}$ and 5.90–6.11 t $ha^{-1}$ $a^{-1}$, respectively [44–48]. The PhytOC production flux in bamboo can be estimated using Eq. (1). The PhytOC flux in studied bamboo varies from 0.017 to 0.081 t $CO_2$ $ha^{-1}$ $a^{-1}$, with a mean of 0.041 t $CO_2$ $ha^{-1}$ $a^{-1}$. The flux among the three ecotypes of bamboo decreases in the order: clustered bamboo $\approx$ mixed bamboo > scattered bamboo (Table 2).

Bamboo distribution area in China is $7.2 \times 10^6$ ha [22]. The area of scattered, mixed and clustered bamboo is $5.76 \times 10^6$ ha, $0.14 \times 10^6$ ha and $1.30 \times 10^6$ ha, respectively [20, 49, 50]. The PhytOC production rate in bamboo can be estimated using Eq. (2). Based on these data and taking the mean PhytOC production flux of three ecotypes of bamboo, the current rate of C sequestration within phytoliths (PhytOC) in Chinese bamboo is

**Table 1** Contents of $SiO_2$, phytoliths and PhytOC among 35 bamboo species of different ecotypes (%)

| Ecotypes | Bamboo species | $SiO_2$ in leaves | | Phytoliths in leaves | | PhytOC in leaves | |
|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | Mean | SD |
| Scattered bamboo | *Chimonobambusa quadrangularis* | 5.41 | 1.01 | 5.16 | 0.20 | 0.22 | 0.012 |
| | *Phyllostachys vivax* McClure cv. *aureocaulis* | 9.21 | 0.76 | 8.17 | 0.21 | 0.12 | 0.010 |
| | *Phyllostachys. parvifolia* | 9.84 | 0.68 | 8.58 | 0.57 | 0.19 | 0.019 |
| | *Phyllostachys imcarnata* | 9.53 | 1.10 | 8.75 | 0.05 | 0.18 | 0.009 |
| | *Phyllostachys vivax f. huanwenzhu* J.L. Lu | 8.33 | 1.07 | 6.83 | 0.12 | 0.16 | 0.014 |
| | *Phyllostachys aureosulcata* | 11.25 | 1.24 | 9.56 | 0.13 | 0.20 | 0.016 |
| | *Phyllostachys bambusoides* var.*castillonis* | 10.47 | 0.87 | 9.28 | 0.25 | 0.17 | 0.012 |
| | *Phyllostachys bambusoides* | 12.75 | 0.81 | 11.20 | 0.22 | 0.18 | 0.003 |
| | *Phyllostachys aureosuleata* McClure cv. Pekinensis J.L. Lu | 8.74 | 0.21 | 6.72 | 0.59 | 0.09 | 0.013 |
| | *Phyllostachys. heterocycla* cv. *huamozhu* | 9.14 | 1.27 | 6.87 | 0.23 | 0.07 | 0.009 |
| | *Phyllostachys propinqua* | 12.64 | 1.24 | 11.10 | 0.40 | 0.42 | 0.009 |
| | *Phyllostachys heterocycla* (Carr.) *Mit ford* | 8.63 | 1.52 | 5.18 | 0.26 | 0.11 | 0.008 |
| | *Phyllostachys prominens* | 5.51 | 0.86 | 3.47 | 0.33 | 0.10 | 0.006 |
| | *Phyllostachys. Arcane* | 11.20 | 0.14 | 9.42 | 1.17 | 0.27 | 0.092 |
| | *Phyllostachys pubescens* | 5.61 | 1.18 | 5.08 | 1.03 | 0.09 | 0.027 |
| | Mean | 9.22 | 0.93 | 7.69 | 0.38 | 0.17 | 0.017 |
| Mixed bamboo | *Sinobambusa tootsik* | 14.62 | 1.69 | 13.45 | 0.62 | 0.28 | 0.076 |
| | *Hibanobambus tranguillans* | 11.40 | 0.63 | 9.75 | 0.27 | 0.16 | 0.005 |
| | *Shibataea chinensis* Nakai | 9.51 | 0.87 | 8.53 | 0.23 | 0.27 | 0.005 |
| | *Shibataea chinensis* | 9.61 | 1.76 | 8.60 | 0.54 | 0.11 | 0.014 |
| | *Shibataea kumasasa* | 11.86 | 2.62 | 9.50 | 0.28 | 0.19 | 0.015 |
| | *Acidosasa gigantea* | 9.84 | 1.11 | 6.59 | 0.43 | 0.12 | 0.011 |
| | *Oligostachyum sulcatum* | 11.83 | 0.72 | 8.59 | 0.50 | 0.13 | 0.016 |
| | *Pseudosasa japonica* | 11.31 | 0.10 | 8.87 | 0.09 | 0.13 | 0.040 |
| | *Pseudosasa japonica* var. *Tsutsumiana Yanagita* | 11.81 | 0.34 | 9.00 | 0.12 | 0.16 | 0.025 |
| | *Pleioblastus kongosanensis* | 17.62 | 1.40 | 12.38 | 0.29 | 0.29 | 0.019 |
| | *Sasa auricoma* | 17.17 | 2.43 | 16.28 | 0.37 | 0.31 | 0.031 |
| | *Sasa argenteastriatus* | 12.37 | 0.47 | 10.33 | 0.15 | 0.23 | 0.007 |
| | Mean | 12.41 | 1.18 | 10.16 | 0.32 | 0.20 | 0.022 |
| Clustered bamboo | *Bambusa multiplex f. alphonsekarri* | 12.33 | 1.15 | 11.07 | 0.27 | 0.24 | 0.022 |
| | *Bambusa multiplex* cv. *Fernleaf* | 14.52 | 2.80 | 12.39 | 0.25 | 0.16 | 0.010 |
| | *Bambusa multiplex* (Lour.) RaeuschelexJ.A.etJ.H.Schul. | 10.18 | 1.73 | 8.17 | 0.26 | 0.15 | 0.013 |
| | *Dendrocalamus latifloru* | 17.06 | 0.57 | 13.69 | 0.41 | 0.28 | 0.020 |
| | *Bambusa vulgaris* | 12.49 | 1.26 | 11.30 | 0.15 | 0.15 | 0.020 |
| | *Bambusa tuldoides* | 14.72 | 0.16 | 11.76 | 0.14 | 0.24 | 0.030 |
| | *Dendrocalamopsis oldhami* | 15.75 | 0.18 | 12.58 | 0.16 | 0.26 | 0.020 |
| | *Bambusa multiplex* cv. *Alphonse*-Karr | 9.73 | 0.15 | 7.78 | 0.06 | 0.17 | 0.020 |
| | Mean | 13.35 | 1.00 | 11.09 | 0.21 | 0.21 | 0.019 |

$0.293 \pm 0.127$ Tg $CO_2$ $a^{-1}$; 75 %, 3 % and 22 % of which are contributed from scattered, mixed and clustered bamboo, respectively (Table 2). Due to the different PhytOC production fluxes and planting areas, the PhytOC production rates vary significantly among the three bamboo ecotypes, and the rate of scattered bamboo is significantly higher than that of mixed or clustered bamboo. The content of PhytOC in dry leaf biomass and the estimated phytolith carbon sequestration fluxes and rates in our study are lower than those found by Parr et al. [11]. This could be explained by (1) the lower ANPP of Chinese bamboo estimated in this study (3.77–8.14 t $ha^{-1}$ $a^{-1}$) as compared to that in Parr et al. [11] and (2) the selection of the mean PhytOC production flux rather than the median value in our PhytOC production rate estimation.

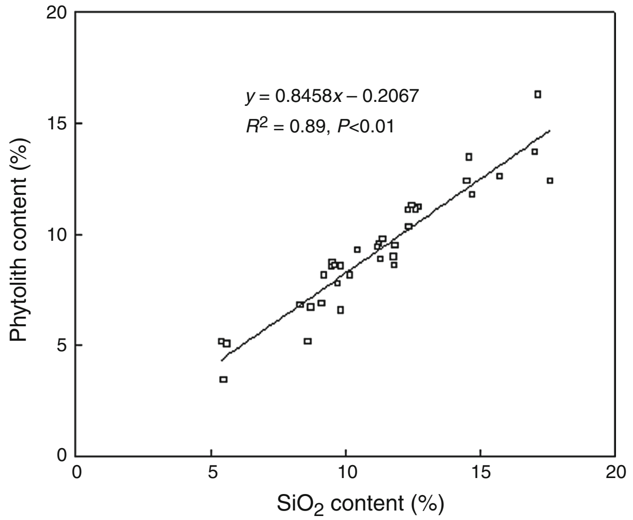


**Fig. 1** Correlation of phytolith content and $SiO_2$ content in bamboo leaf litter

Although the production rate of PhytOC in bamboo is lower than grasslands and fens due to its smaller distribution area, the phytolith C sequestration flux of bamboo is higher than that of grassland, millet and fen (Table 3).

### 4.3 The implication for phytolith carbon sequestration in global bamboos

Taking the mean PhytOC production flux of 0.041 t $CO_2$ $ha^{-1}$ $a^{-1}$ (Table 2) and the current global bamboo area of $22 \times 10^6$ ha, approximately 0.89 Tg $CO_2$ from the atmosphere would be sequestrated globally by various bamboo species every year. It is possible to enhance the potential phytolith carbon sequestration rate by improving the actual phytolith production flux of bamboo and increasing the area of bamboo forest. Although the phytolith carbon production flux of bamboo in our study is low, it is possible to improve it to $0.18 \pm 0.12$ t $CO_2$ $ha^{-1}$ $a^{-1}$ (half of the result of Parr et al. [11]) by regulating silicon supply such as the applications of Si fertilizers [38–41] and Si-rich organic mulches [42, 43]. The current global area of bamboo forest is $22 \times 10^6$ ha, however, it will have tripled by 2050 given the current annual area growth rate of 3 % [11, 25]. Taking the production flux ($0.18 \pm 0.12$ t $CO_2$ $ha^{-1}$ $a^{-1}$) of PhytOC and the tripled area, the phytoliths of global bamboo would be expected to sequester $11.9 \pm 7.9$ Tg $CO_2$ $a^{-1}$ from the atmosphere in 2050.

In comparison with other plant ecosystems (Table 4), the global potential rate of bamboo PhytOC production in this study and that of Parr et al. [11] is similar to that of rice due to its smaller distribution area [2], but higher than that of sugarcane, fen and millet [3, 15, 17].

Sequestration of atmospheric $CO_2$ in the terrestrial biosphere is an effective mechanism for reducing atmospheric

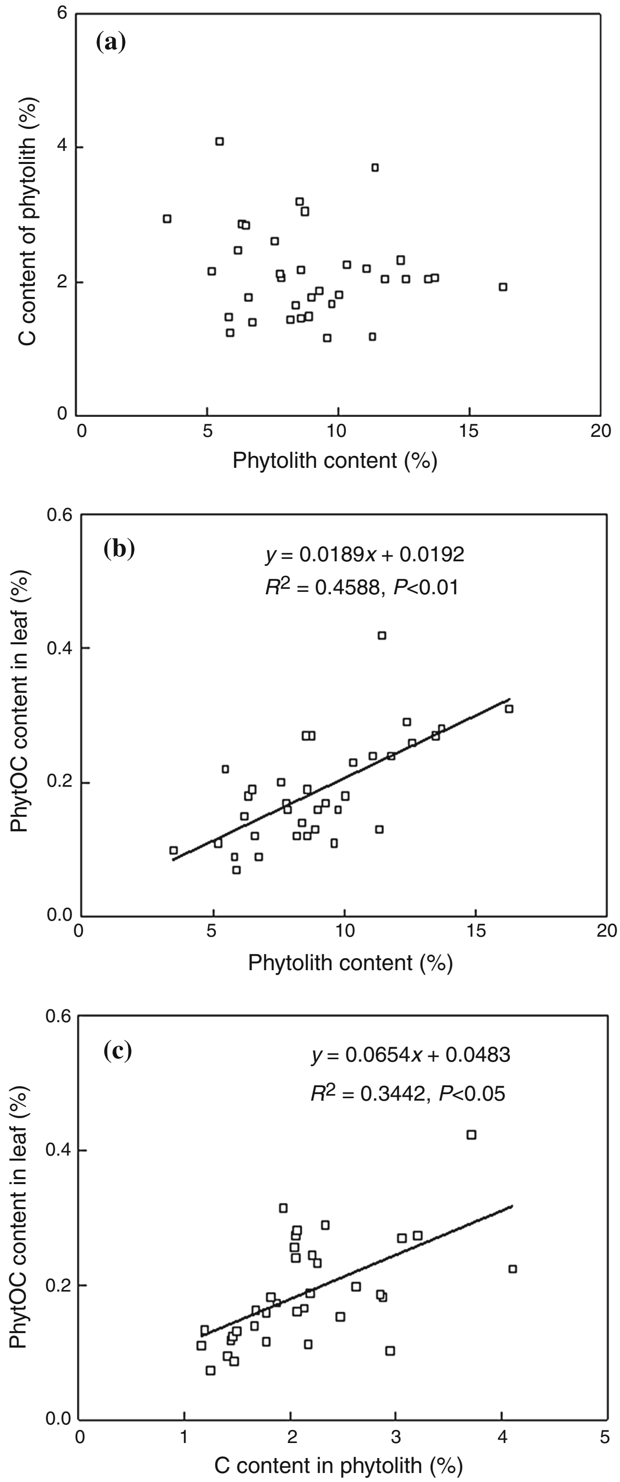


**Fig. 2** Correlations among C content of phytolith, phytolith content and PhytOC content in leaf litter. **a** C content of phytolith vs phytolith content; **b** PhytOC content in leaf litter and phytolith content; **c** PhytOC content in leaf litter and C content in phytolith

$CO_2$ concentration. It is possible to relieve some of the adverse impacts of climate change by selecting and growing plants with high phytolith content and a strong capacity to

**Table 2** The mean PhytOC production fluxes and rates of three ecotypes of bamboo (SD)

| Ecotypes | Area ($10^6$ ha) | Estimated PhytOC fluxes (t $CO_2$ $ha^{-1}$ $a^{-1}$) | Estimated PhytOC rates (Tg $CO_2$ $a^{-1}$)[b] |
|---|---|---|---|
| Scattered bamboo | 5.76 | 0.038 (0.020) | 0.220 (0.110) |
| Mixed bamboo | 0.14 | 0.049 (0.016) | 0.007 (0.002) |
| Clustered bamboo | 1.30 | 0.050 (0.016) | 0.065 (0.015) |
| Total | 7.20 | 0.041 (0.017) | 0.293 (0.127) |

[b] 1 Tg = $10^{12}$ g

**Table 3** Comparison of estimated PhytOC fluxes and PhytOC production rates in different ecosystems of China

| Plant species | PhytOC in leaves (%) | PhytOC production fluxes (t $CO_2$ $ha^{-1}$ $a^{-1}$) | PhytOC production rate (Tg $CO_2$ $a^{-1}$) | Ref. |
|---|---|---|---|---|
| Bamboo | 0.07–0.31 | 0.017–0.081 | 0.292 (0.120) | This study |
| Grassland | 0.04–0.06 | 0.001–0.002 | 0.600 (0.171) | [7] |
| Millet | 0.04–0.27 | 0.008–0.038 | 0.042 (0.028) | [17] |
| Fen | 0.01–0.25 | 0.003–0.077 | 0.545 (0.493) | [3] |

The number within parenthesis is standard deviation

**Table 4** Comparison of estimated PhytOC fluxes and global potential PhytOC production rates in different ecosystems

| Plant species | PhytOC production fluxes (t $CO_2$ $ha^{-1}$ $a^{-1}$) | Potential PhytOC production rates (Tg $CO_2$ $a^{-1}$) | Ref. |
|---|---|---|---|
| Bamboo[a] | 0.067–0.319 | 4.0–19.8 | This study |
| Economic bamboo | 0.008–0.709 | 7.8–15.6 | [11] |
| Sugarcane | 0.120–0.360 | 2.4–7.2 | [15] |
| Rice | 0.026–0.125 | 3.9–19.4 | [2] |
| Fen | 0.003–0.077 | 1.0–11.4 | [3] |
| Millet | 0.008–0.038 | 0.5–2.7 | [17] |

[a] The potential area of world's bamboo is expected to reach 66 × $10^6$ ha by 2050 [11, 25]

occlude C within their phytoliths [11]. In spite of some uncertainties in calculating bamboo phytolith and PhytOC production, caused mainly by regional or species variation, the results of the study indicate that bamboo phytoliths have great potential to occlude $CO_2$ because of their outstanding peculiarities of high phytolith content, rapid growth and reproduction and ease of regeneration. Therefore, bamboo forests have significant potential to mitigate the increasing concentration of atmospheric $CO_2$ if maximizing the production of PhytOC and expanding bamboo distribution area.

## 5 Conclusions

The PhytOC content of different bamboo species of three ecotypes (scattered, mixed and clustered bamboo) ranges from 0.07 % to 0.42 %. Generally, the dry mass of phytoliths and PhytOC within the three ecotypes of bamboo decrease in the order: clustered ≈ mixed > scattered bamboo. The data indicate that the mean PhytOC production flux likewise decreases in the order: clustered bamboo (0.050 ± 0.016 t $CO_2$ $ha^{-1}$ $a^{-1}$) ≈ mixed bamboo (0.049 ± 0.016 t $CO_2$ $ha^{-1}$ $a^{-1}$) > scattered bamboo (0.038 ± 0.020 t $CO_2$ $ha^{-1}$ $a^{-1}$). The C sequestration rate within phytoliths (PhytOC) in Chinese bamboo is estimated to be about 0.293 ± 0.127 Tg $CO_2$ $a^{-1}$; 75 %, 3 % and 22 % of which are contributed from scattered, mixed and clustered bamboo, respectively. Taking the potential production flux of PhytOC (0.18 ± 0.12 t $CO_2$ $ha^{-1}$ $a^{-1}$) and potential bamboo area (66 × $10^6$ ha), 11.9 ± 7.9 Tg $CO_2$ $a^{-1}$ from the atmosphere would be sequestered in bamboo phytoliths globally in 2050.

Although our method is not complex, we think that our study offers a rough estimation of phytolith carbon sequestration in bamboo forest of China and of the world, which allows for direct comparison of phytolith carbon sequestration among different terrestrial ecosystems and offers references for bamboo afforestation or reforestation practices. Further study on the effects of management practices (e.g., rock-powder amendment and silica fertilization) on bamboo phytolith C sequestration is required before practices of bamboo phytolith C sequestration enhancement can be used to reduce the concentration of greenhouse gases in the atmosphere at a regional or global scale.

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**Conflict of interest** The authors declare that they have no conflict of interest.

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