Transect-scale controlling factors for soil microbial biomass carbon

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Abstract

Soil microbial biomass carbon (MBC) plays an essential role in driving and regulating global cycling of carbon (C) which is critically important to climate system. However, the pivotal transect-scale determinant factor for the content of soil MBC, along with the variation pattern in different natural forests and soils has not been sufficiently investigated. In this study, 252 soils (6 replicates and 3 depths for each site) were sampled from 14 forests which lie in 7 soil types along the 4000 km North-South transect of Eastern China. We found that the highest content of MBC in the whole soil profile with 556.69 ±14.59 mg C kg^{-1} occurred in the subalpine coniferous forest, and the lowest content was observed with 53.11 ±10.22 mg C kg^{-1} in warm coniferous forest. From the angle of soil type, in the whole soil profile Haplic Andosol had the highest content of soil MBC with 480 mg C kg^{-1}, while Haplic ferralsol possessed the lowest content of MBC with 102 mg C kg^{-1}. In addition, over the North-South transect of Eastern China the strongest correlation was observed in between the content of soil MBC and ALT (R^2 = 0.64), followed by soil type (R^2 = -0.61), MAT (R^2 = -0.56). We concluded that the content of soil MBC in natural forests is mainly controlled by ALT on a transect scale. We believed that the soil C in Yue spruce-fir forest was relatively stable, which can be an option to be a specific forest to optimize forest management and to contribute to mitigating climate change.

Keywords: microbial biomass carbon; altitude; nature forests; North-South transect of Eastern China

1. Introduction

Soil microbes play an essential role in driving and regulating the global cycling of carbon (C) which is vital to climate change (Delgado-Baquerizo et al., 2016; Melillo et al., 2002; Singh et al., 2010). The soil microbial biomass carbon (MBC) in forests, the largest terrestrial ecosystem (Schimel et al., 2001), may strengthen or weaken carbon-climate feedback (Cotrufo et al., 2019; Allison et al., 2010; Janssens et al., 2010), so, it is critical to climate change induced by rising CO_2 concentrations in the atmosphere (Soucémarianadin et al., 2019; Liang et al., 2017; Singh et al., 2010).The soil MBC, although accounting for a small proportion of soil organic carbon (SOC) (Ramírez et al., 2020; Bolan et al., 2011), is proposed to be an effective indicator to detect significant changes in SOC (Spohn et al., 2016; Knorr et al., 2005). In addition, the soil MBC can reflect the stability of the SOC (Benbi et al., 2012; Benbi et al., 2014), soil quality and functions (Benbi et al., 2014; Bongiorno et al., 2019), due to its sensitivities to environmental changes (Guimarães et al., 2013; Hok et al., 2021). Acquiring more knowledge about the large-scale key controlling factor and spatial pattern of MBC is critically vital to understand not only the global C cycling (Allison et al., 2010; Xu et al., 2013), but also the microbial biogeography (Martiny et al., 2006).

The high spatial heterogeneity of soil properties, diversity of forest ecosystems, and complexity of climate conditions lead to large variations in the content of soil MBC. An extensive number of studies have investigated the effect of different variables on the content of MBC (Treseder, 2008; Zeller and Dambrine, 2011; Khan et al., 2016). Nevertheless, there are less studies on transect-scale controlling factors for the content of soil MBC and discrepancies between the current studies results (Cleveland and Liptzin, 2007; Joergensen et al., 2011; Kirschbaum et al., 2006). For example, Cleveland and Liptzin (2007) reported that there was a positive relation between the content of soil MBC and C/N ratios (Cleveland and Liptzin, 2007), whereas Demisie et al. (2014) found a negative relationship between them (Demisie et al., 2014). Furthermore, Some studies showed that soil pH had a positive or negative significant effect on the content of soil MBC (Fierer and Jackson, 2006; Khan et al., 2016), or there was no correlation between them (Bauhus et al., 1998; Xu et al., 2013). Moreover, regarding environmental factors like temperature, moisture, vegetation or altitude, there were still controversial results in research studies (Melillo et al., 2011; Bargali et al., 2018; Xu et al., 2013). Serna-Chavez et al. (2013) reported that moisture availability rather than temperature was the primary factor for the changes in the soil microbial biomass, but other studies suggested that temperature and moisture had no impact on soil microbes in a short time (Manzoni et al., 2012; Benbi et al., 2014). Most of the current studies sampling on a limited site (Milcu et al., 2011; Benbi et al., 2014; Allison et al., 2010), little is known on the variation pattern of the content of soil MBC in a near continental scale and universal framework for explaining the key transect-scale controlling factor for the content of soil MBC, which could provide more comprehensive and profound information about the global C dynamics, as well as would help us develop the sustainable forest management including soil C sequestration to mitigate climate change.

Targeting the current knowledge gaps, we therefore chose the near 4000 km North-South transect of Eastern China, recognized as the 15th standard transect of the International Geosphere-Biosphere Programme (IGBP) (Zhang and Yang, 1995; Steffen et al., 1999), to sample soils from 14 forests, seven soil types and three depths. The study aims to 1) investigated the spatial pattern of the content soil MBC along the variable gradients over the North-South transect of Eastern China 2) and evaluate the critical transect-scale controlling factor for the content of soil MBC content. We hypothesized there would be more content of soil MBC in temperate forests and the essential factor for it would be the mean annual temperature (MAT) or the altitude (ALT).

2. Materials and Methods

2.1 Study site and soil sampling

We chose the North-South Transect of Eastern China (109.5˚E ~128˚E, 18.73˚N ~ 53˚N) as our study site, which is the 15th transect of IGBP. The transect with the MAT of -4~24℃, the MAP of 420~1750 mm, the distance of more than 4000 km from north to south, covers soil types from Haplic Podzol in cold temperate areas to Haplic Acrisol in subtropical regions, and then to Rhodic Ferralsol in tropical areas, and contains most of the Northern Hemisphere forest types from coniferous forests of cold temperate to rain forests of tropical, which are mainly controlled by the summer monsoon of East Asia (Fig. 1, Table 1) (Zhang and Yang, 1995).

In September and October 2019 and June 2020, soil samples were collected from Dinghu, Shennong, Dongling and Changbai long-term forest ecosystem stations that are evenly distributed in the crucial climate zones of the North-South transect and almost all located in the National Nature Reserve. The four ecosystem stations are Changbaishan Forest (CF, 128.47˚E, 42.4˚N), Beijing Donlingshan Forest (BF, 115.43˚E, 39.97˚N), Shennongjia Forest (SF, 110.05˚~110.57˚E, 31.32˚~31.6˚N) and Dinghushan Forest (DF, 112.5˚~112.55˚E, 23.15˚~23.18˚N), respectively. At each station, soil samples were collected from different forests with different elevations from foot slope to summit (Fig.1). In CF, Korean pine broadleaf forest, Korean pine spruce-fir forest, Yue spruce-fir forest, Yue birch forest were chosen. In BF, a warm temperate deciduous broadleaf forest was selected. Evergreen broadleaf forest, evergreen deciduous broadleaf mixed forest, deciduous broadleaf forest, subalpine coniferous-broadleaf mixed forest, subalpine coniferous forest, were selected in SF, and mountain evergreen broadleaf forest, conifer-broadleaf mixed forest, monsoon evergreen broadleaf forest, warm coniferous forest, were selected in DF (Table 1). In each forest type, we selected six representative plots, which were measured as 20 m×20 m with a distance of at least 15 m between each plot. Three subplots were randomly settled in each plot and within each subplot the fresh, green undecomposed litter material and small pebbles or stones were removed. To prepare a representative sample of the whole plot, three soil layers (0-20 cm, 20-40 cm, 40-60 cm) were sampled with a stainless-steel corer with a five-centimeter diameter, and thoroughly mixed corresponding layers. Positional information including longitude, latitude, and elevation were simultaneously obtained from a GPS device. Typically, soil samples were divided into two major parts, one part being refrigerated at 4 °C and the other part being air dried, and homogenized with a sieve (< 2 mm) to determine the physical and chemical parameters. The soil samples were sealed in polyethylene bags prior to use.

2.2 Soil physical and chemical parameters

Soil organic carbon (SOC) was determined by dichromate oxidation and titration with ferrous ammonium sulphate (Jones, 2001). Soil total carbon (STC) and total nitrogen (STN) were measured with the Elemental Analyzer (PerkinElmer 2400 II, USA).

Microbial biomass carbon (MBC) content was determined by the chloroform fumigation-extraction method (Vance et al., 1987). The content of MBC was calculated as follows:

$$\text{MBC} = \frac{E_c}{kE_c} \quad (1)$$

where E_C is the organic C extracted from fumigated soils minus organic C extracted from non-fumigated soils and kE_C is the extractable part of microbial biomass C after fumigation. According to the literature and experimental data (Vance et al., 1987; Joergensen, 1996; Joergensen et al., 2001), we measured kE_C as 0.45.

2.3 Statistical analysis

Statistical analysis was performed with SPSS 26.0 and Arcgis 10.4. Graphics were processed by Origin 2022b. One-way analysis of variance (ANOVA) with post hoc multiple comparisons utilizing a least significant difference (LSD) test with $p < 0.05$ as the cut-off value indicated significant differences of the MBC content in different variables. Correlation measures how closely related the MBC content and influencing factors by calculating the correlation coefficient using Pearson and Spearman correlation analysis. The specific slope value was acquired by analyzing the digital elevation model (DEM) of the corresponding study areas using 3D analyst tools with raster surface in Arcgis 10.4 and referencing to some records of sampling.

3. Results

3.1 The content of soil MBC in different forests

The content of soil MBC differed significantly ($p < 0.01$) in the 14 forests along the North-South transect of Eastern China (Fig. 2). In the upper 20 cm soil layer, the highest content of MBC with 916±77 mg C kg^{-1} was observed in Korean pine broadleaf forest (CI), while the lowest content with 94±8 mg C kg^{-1} occurred in warm coniferous forest (DIV). Simultaneously, there were higher content of MBC also in Yue birch forest (CIV, 812±35 mg C kg^{-1}) and subalpine coniferous forest (SV, 782±28mg C kg^{-1}). However, the highest and lowest content of MBC occurred in subalpine coniferous (SV) and warm coniferous forests (DIV) at the depth of 20-40 cm, with 501± 23 mg C kg^{-1} and 30 ±1 mg C kg^{-1}, respectively. At the depth of 40-60 cm, subalpine coniferous (SV) and warm coniferous forests (DIV) possessed the highest and lowest content of MBC, with 387±16 mg C kg^{-1} and 35±8 mg C kg^{-1}, respectively. In general, the Yue birch forest and the warm coniferous forest had the highest and lowest content of MBC in the whole soil profile (Fig.2).

The content of soil MBC in the 14 forests decreased from surface soil to subsoil, namely the content of MBC in the upper 20 cm soil layer was far higher than that at the depth of 20-40 cm and 40-60 cm. Nevertheless, there was no regular trend of MBC content from the depth of 20-40 cm to 40-60 cm. For example, in some kinds of forests, i.e. Korean pine broadleaf forest (CI), deciduous forest (SIII), monsoon evergreen broadleaf forest (DIII), the content of MBC increased with the depth of 20-40 cm to 40-60 cm (Fig.3). In general, the content of soil MBC decreased with increasing soil depth, yet it appeared to show that there was no consistent regular trend in subsoil along the North-South transect of Eastern China (Fig. 2).

3. 2 The variation of MBC content in soil types

In terms of soil type, in the upper 20 cm soil layer the highest content of MBC with a mean of 849±64 mg C kg^{-1} occurred in Haplic Luvisol, and the lowest content of MBC was observed in Haplic ferralsol with a mean of 150±31 mg C kg^{-1} (Fig. 3). Also, Haplic Andosol represented higher content of MBC with a mean of 812±35 mg C kg^{-1} in the upper 20 cm soil layer. At the depth of 20-40 cm, the highest and lowest content of MBC occurred in Haplic Andosol and Haplic ferralsol, with 343 ±65 mg C kg^{-1} and 71±26 mg C kg^{-1}. Haplic Luvisol had the second higher content of MBC with 310±81 mg C kg^{-1}. At the depth of 40-60 cm, Haplic Andosol and Haplic Podzol had the highest and lowest content of MBC with 285±72 mg C kg^{-1} and 65±19 mg C kg^{-1}, respectively. In general, Haplic Luvisol and Haplic Andosol had relatively higher content of MBC, while Haplic ferralsol possessed lower content of MBC (Fig.3).

3.4 The proportion of MBC in SOC

The proportion of MBC in SOC ranged from 0.5% to 4% (Fig.4) at any soil depth in the 14 forests along the North-South transect of Eastern China, most of which were less than 2% (Fig. 4). In the upper 20 cm soil layer, we found that the higher ratio of MBC in SOC with 3.9%, 2.4%, 2% occurred in CI, SIV, SV, i.e. Korean pine broadleaf forest, subalpine coniferous-broadleaf mixed forest, subalpine coniferous forest, however, the lower ratios were observed with 0.8%, 0.7%, 0.5% in CIII, DIII and DIV (Yue spruce-fir forest, monsoon evergreen broadleaf forest and warm coniferous forest). Similarly, at the depth of 20-40 cm, the higher proportions of MBC accounting for SOC with 3.0%, 3.1%, 2.6% were still found in CI, SIV, SV, and the lower proportions were still observed with 0.5%, 0.4%, 0.3% in CIII, DIII and DIV. There was the same trend at the depth of 40-60 cm (Fig. 4). In a word, the Yue spruce-fir and warm coniferous forest possessed the lowest ratio of MBC in SOC.

3.5 Correlation between the content of MBC and environmental factors

The content of MBC at any soil depth in the 14 forests strongly correlated with soil type, MAT, ALT ($p<0.01$) (Table 2). At the depth of 0-20 cm, the content of MBC most strongly negatively correlated with soil type (R^2=-0.76), followed by MAT (R^2=-0.70), ALT(R^2=-0.53) and forest type (R^2=-0.53) (Table 2). However, with increasing soil depths ALT became the strongest correlation factor with the content of MBC. At depths of 20-40 cm and 40-60 cm, the most strongly positive correlation factor was ALT with the correlation coefficients 0.64 and 0.47, respectively (Table 2). The correlation degree between MAT or soil type and the content of MBC became weakly with the soil depth increasing. Forest type and mean annual precipitation (MAP) were no longer correlated with the content of MBC in subsoil. In the whole soil profile (0-60 cm), ALT, soil type and MAT were the critical transect-scale factors for the content of MBC.

4. Discussion

4.1 Variation in MBC content along the transect

In this study, it was found that the higher content of MBC was observed in northern temperate than in southern tropical forests (Fig.2). This is consistent with previous studies reporting that the concentration of C in soil microbial biomass was relatively higher in northern high latitudes and relatively less at low latitudes and the Southern Hemisphere (Xu et al., 2013; Post et al., 1982). In terms of specific forest type, we found that the content of MBC (0-20 cm) were generally higher, yet not statistically significant, in broadleaf forests compared to coniferous forests (Fig.2). This finding was consistent with previous studies which reported that there were fewer soil microbial biomass under conifers forest than under broadleaf forests (Xu et al., 2013). However, with increasing soil depth, coniferous and birch forests were found to have higher content of MBC (Fig.2). It may be explained by the reason that soil microbial biomass content is normally limited by the amount of C in the soil (Soong et al., 2020; Allison et al., 2010; Xu et al., 2013). Furthermore, in coniferous and birch forests along the North-South transect of Eastern China there is more C accumulated in the subsoil (Gu et al., 2022) because of the root exudates with higher content of organic acids and amino acid (Li et al., 2004; Bradley and Fyles, 1995), which is the main energy source for microbes (Helal and Sauerbeck, 2007) and this may result in more living microorganisms, thereby ultimately leading to more C in microbial biomass in subsoil of the two forest types.

Regarding the soil type, we found that the highest content of MBC occurred in Haplic Luviosl (Fig. 3), which is supported by the previous study that suggested the Luviosls having relative fine-textured contained more C when compared to the Podzols coarse-textured (Bargali et al., 2018; Bauhus et al., 1998). This could be explained by the fact that there is a slower turnover of soil microbial biomass or lower rate of microbial decomposition on fine-textured soils that have a lower C/N ratio (Spohn et al., 2016; Hassink, 1994) than on coarse-textured soils (Bargali et al., 2018; van Veen et al., 1987). Furthermore, microbes in fine-textured soils may be better protected against desiccation than in coarse-textured soils, resulting in more C being present in soil microbes within Luvisol.

In our study, higher content of MBC was observed in the upper 20 cm soil layer than in the subsoil (Fig. 2), which is consistent with previous studies reported that the amount of MBC in the upper few centimeters of the surface soil can be 100 times larger than that below 100 cm (Spohn et al., 2016; Xu et al., 2013; Ekelund et al., 2001). This may be ascribed to the reason that the humus layer from various plant residues lies in the upper part of the whole soil profile, thereby directly contributes to providing energy to soil microbes in topsoil, which leads to more soil microorganisms living there (Spohn et al., 2016; Lai et al., 2016).The amount of plant root exudates which is another source (Helal and Sauerbeck, 2007) for MBC is less than that of humus in surface soil, and the lack of readily available organic C in subsoil (Fontaine et al., 2007), ultimately resulting in the general phenomenon of MBC decreasing with increasing soil depth (Janssens et al., 2002).

4.2 The proportion of MBC in SOC

The proportion of MBC in SOC ranged from 0.5% to 4% (Fig.4), which is consistent with previous studies (Wang et al., 2018; Anderson and Domsch, 1989). Currently, most of studies believe that the ratio of MBC in SOC is relatively stable in a long time (Anderson and Domsch, 1989; Sparling,1992). The higher proportion of MBC in SOC means that the C that should be into soil is priority utilized by microorganism, which result in less C in soil and suggest that the C remaining in soil is relatively stable due to its hardly to be available. In our study the highest proportion of MBC accounting for SOC occurred in Korean pine broadleaf (CI), subalpine coniferous-broadleaf mixed (SIV) and subalpine coniferous forest (SV) that had lowest SOC content (Gu et al., 2022), which indicated that the soil C in these forests is unstable (Sparling, 1992). In contrast, the forests, e.g. Yue spruce-fir forest (CIII), monsoon evergreen broadleaf forest (DIII) and warm coniferous forest (DIV), with lower proportion of MBC accounting for SOC had relatively stable soil C.

4.3 Correlation between MBC content and influencing factors

We found that ALT, soil type and MAT most closely correlated with the content of MBC (Table 2), which is consistent with previous studies (Liu et al., 2021; Chuckran et al., 2023; Lange et al., 2015).

Different soil forming process between different soil type may affect the content of MBC by influencing the dominant species (bacteria or fungi) (Chuckran et al., 2023; Groffman et al.,1996; Bauhus et al., 1998). Through its own physiochemical properties, structure and aeration, soil type has a direct impact on the size and activity of soil microbial community (Chuckran et al., 2023; Bauhus et al., 1998).

We found that MAT was the most negative correlation factor for the content of MBC in the upper 20 cm soil layer (Table 2), which is consistent with previous studies (He and Xu, 2021; Bryant et al., 2008; Manzoni et al., 2012) that reported climate factors had the largest impact on the soil microbial community. Some studies pointed out that temperature may also modify the microbial community structure (Xu et al., 2015; Ren et al., 2018) and then to affect the quantity of MBC. In addition, MAT can affect the process of the decomposition of plant litter (Gu et al., 2022) which is one of the energy sources for microbes, further influencing microbial growth and the content of MBC (Paul, 2014; Xu et al., 2013). Furthermore, temperature is the primary factor affecting the survival, metabolism and biology mechanism of soil microbes (Margesin and Collins, 2019; Yin et al., 2022) and then influence its contribution to the overall soil C pool (Bahram et al., 2012; Cregger et al., 2012; Rosling et al., 2011). Additionally, forest type affects species or communities of microbes through various decomposition processes of different litter species or root exudates (Bargali et al., 2018; Hagen-Thorn et al., 2004; Ahmed et al., 2016), ultimately leading to the large variability of the content of MBC in different forest ecosystems (Melillo et al., 2011; Li et al., 2004).

However, in the upper 60 cm soil layer, the content of MBC strongly positively correlated with ALT (R^2= 0.64), which is different from previous studies that suggested microbial biomass negatively related to altitude (Xu et al., 2015; Ren et al., 2018). The discrepancy may be ascribed to the different study scales, namely our study provided objective and profound conclusions in a near continental scale, 4000 km North-South transect. In addition, the complex environmental conditions (Bahram et al., 2012) composed of changing oxygen concentration, varied climate temperature, and precipitation, which are induced by altitude gradients, resulting in different soil microbial biodiversity or activity (Mayor et al., 2017; Ren et al., 2018), further to affecting the C in microbial biomass. Forests at high altitudes have more fine roots than those at low altitudes (Jackson et al., 1996), which supply more root exudates as energy to microorganisms and thus favor the growth of microbials, ultimately leading to higher C in microbial biomass at higher altitudes (van Diepen et al., 2007). Compared to previous studies (Xu et al., 2015; Ren et al., 2018), we may believe that the content of MBC may increase with increasing ALT within a range of altitude, but decrease beyond the range. The cut-off value for the content of MBC in altitude and what model of the MBC content changing with altitude need to be further explored.

In summary, soil type, MAT, ALT were the most critical factors for the content of

MBC along the North-South transect of Eastern China. Knowledge of the trends in the content of MBC at the near continental scale contributes to innovative selection of specific forest types to optimize soil C sequestration for climate change mitigation.

5. Conclusions

Subalpine coniferous and warm coniferous forests had the highest and lowest content of MBC, respectively. Haplic Luvisol and Haplic Andosol possessed the highest content of MBC, but Haplic ferralsol had the lowest amount. ALT, soil type and MAT were the most critical transect-scale factors for the content of MBC. Yue spruce-fir forest had larger potential of soil C sequestration due to its relatively stable soil C.

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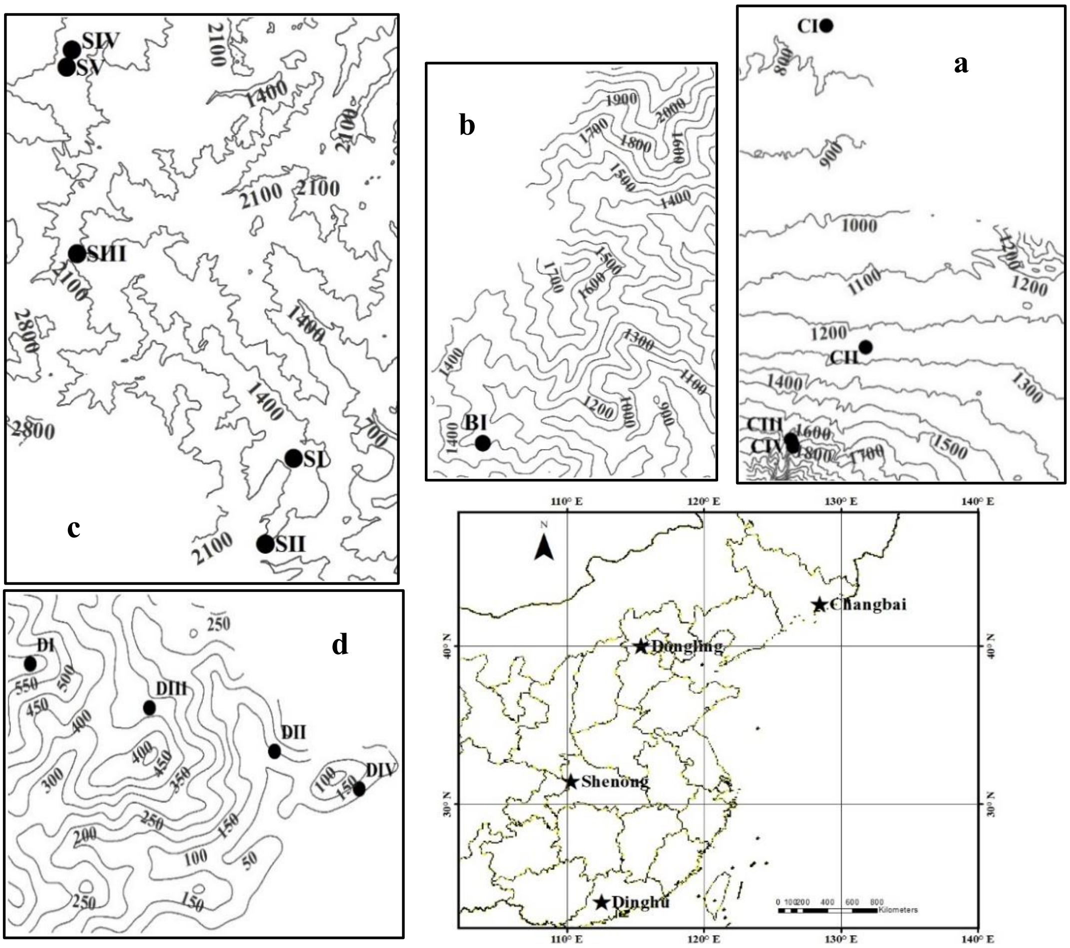

Fig. 1. Map of study area and distribution of soil sampling sites along the North-South transect of Eastern China. Graphs a-d were different forest ecosystems of Changbai, Bejing Doling, Shennong, Dinghu, respectively. The abbreviations are as follows: CI, Korean pine broadleaf forest; CII, Korean pine-spruce fir forest; CIII, Yue-spruce fir forest; CIV, Yue birch forest; BI, warm temperate deciduous broadleaf forest; SI, evergreen broadleaf forest; SII, evergreen deciduous broadleaf mixed forest; SIII, deciduous broadleaf forest; SIV, subalpine coniferous-broad mixed forest; SV, subalpine coniferous forest; DI, mountain evergreen broadleaf forest; DII, conifer-broad mixed forest; DIII, monsoon evergreen broadleaf forest; DIV, warm coniferous forest.

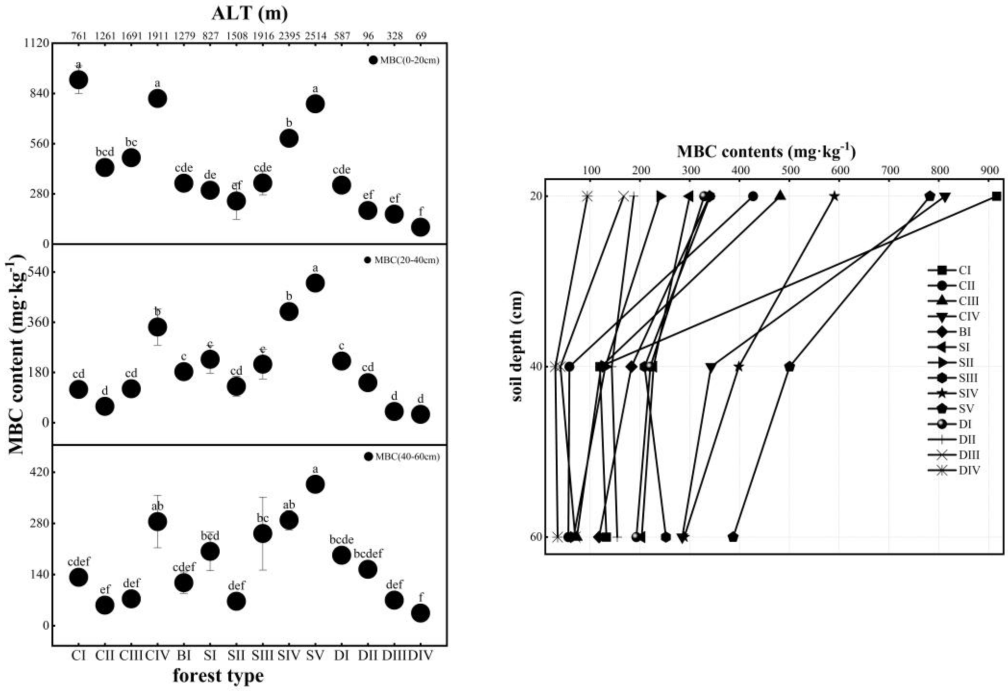

Fig. 2. The content of soil microbial biomass carbon at different soil depths in the 14 forests along the North-South transect of Eastern China. The abbreviations are as follows: CI, Korean pine broadleaf forest; CII, Korean pine-spruce fir forest; CIII, Yue-spruce fir forest; CIV, Yue birch forest; BI, warm temperate deciduous broadleaf forest; SI, evergreen broadleaf forest; SII, evergreen deciduous broadleaf mixed forest; SIII, deciduous broadleaf forest; SIV, subalpine coniferous-broad mixed forest; SV, subalpine coniferous forest; DI, mountain evergreen broadleaf forest; DII, conifer-broad mixed forest; DIII, monsoon evergreen broadleaf forest; DIV, warm coniferous forest.

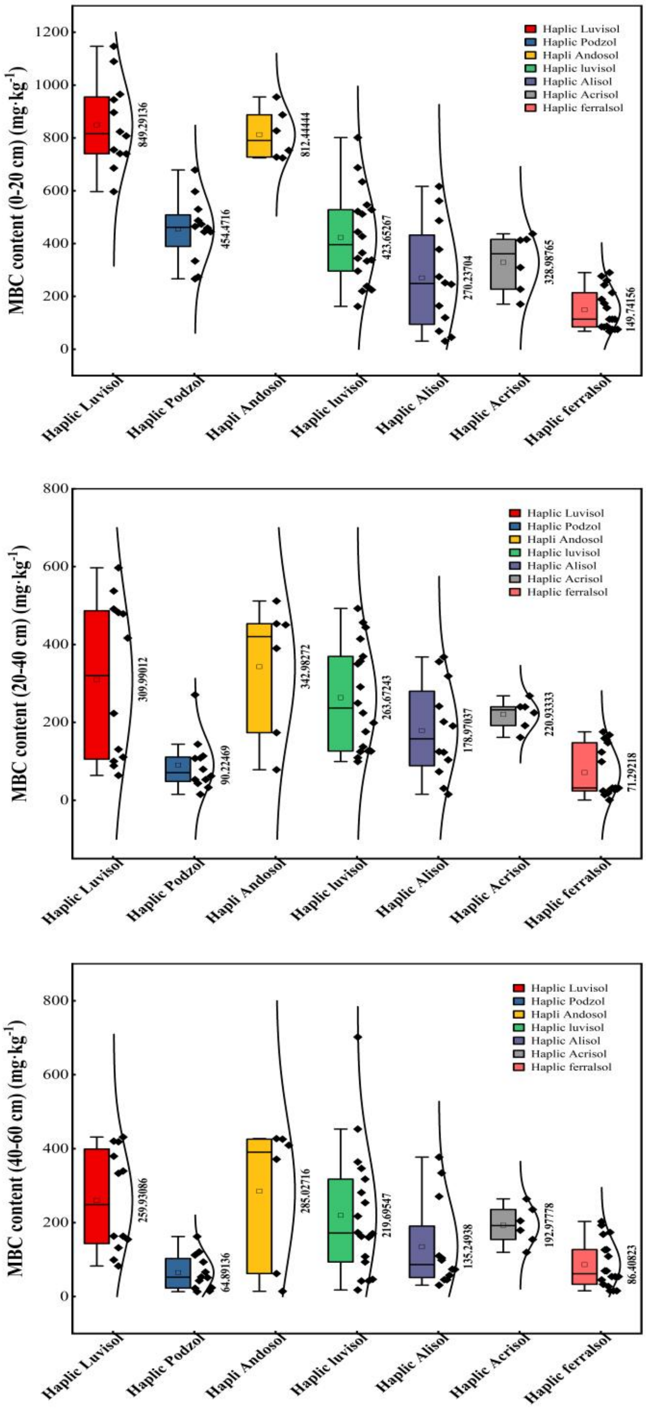

Fig. 3. The content of soil microbial biomass carbon at different depths in different soil types along the North-South transect of Eastern China.

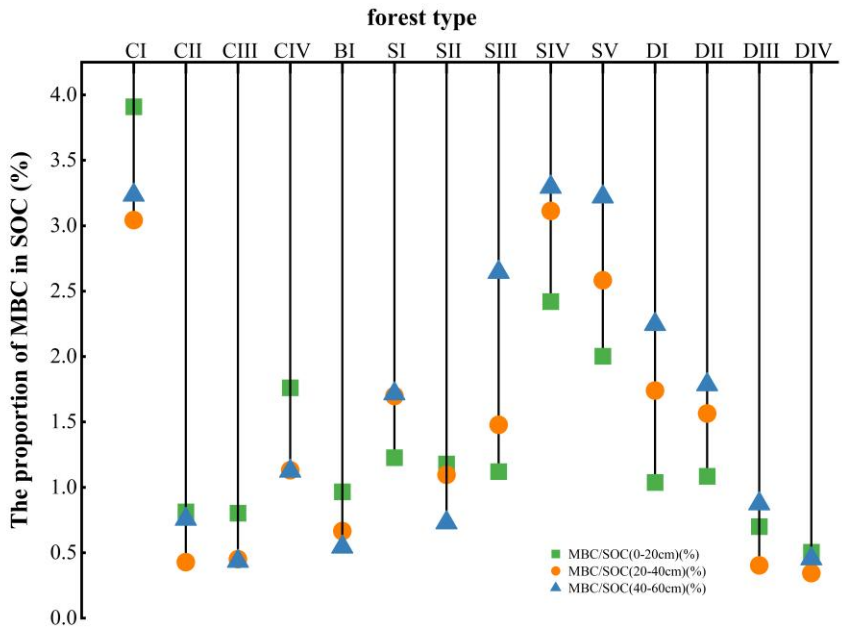

Fig. 4. The proportion of MBC accounting for SOC at different depths in the 14 forests along the North-South transect of Eastern China.

Table 1

Main characteristics of the soil sampling sites along the North-South transect

Sampling sites		LAT (N)	LON (E)	MAT (°C)	MAP (mm)	ALT(m)	Slope	Forest type	Soil type
Changbai (CF)	CI	42.4018°	128.0953°	3.5	700	761	1°	Korean pine broadleaf forest	Haplic Luvisol
	CII	42.1414°	128.1284°	2	800	1261	2°	Korean pine spruce-fir forest	Haplic Podzol
	CIII	42.0667°	128.0659°	1.5	900	1691	19°	Yue spruce-fir forest	Haplic Podzol
	CIV	42.0610°	128.0680°	0.5	1000	1911	20°	Yue birch forest	Haplic Andosol
Beijing Dongling (BF)	BF	39.9580°	115.4256°	4	600	1279	19°	Warm temperate deciduous broadleaf forest	Haplic luvisol
Shennong (SF)	SI	31.3689°	110.4988°	16.5	970	827	34°	Evergreen broadleaf forest	Haplic Alisol
	SII	31.3086°	110.4777°	13	1200	1508	27°	Evergreen deciduous broadleaf mixed forest	Haplic Alisol
	SIII	31.5139°	110.3413°	10	1300	1916	24°	Deciduous broadleaf forest	Haplic luvisol
	SIV	31.6576°	110.3374°	6	1500	2395	32°	Subalpine coniferous-broadleaf mixed forest	Haplic luvisol
	SV	31.6454°	110.3337°	4	1600	2514	21°	Subalpine coniferous forest	Haplic Luvisol
Dinghu (DF)	DI	23.1759°	112.5235°	19.79	1980	587	28°	Mountain evergreen broadleaf forest	Haplic Acrisol
	DII	23.1687°	112.5483°	21.01	1930	96	15°	Conifer-broadleaf mixed forest	Haplic ferralsol
	DIII	23.1723°	112.5356°	20.9	1956	328	20°	Monsoon evergreen broadleaf forest	Haplic ferralsol
	DIV	23.1657°	112.5570°	22.66	1910	70	23°	Warm coniferous forest	Haplic ferralsol

The abbreviations are as follows: LAT, latitude; LON, longitude; MAT, mean annual temperature; MAP, mean annual precipitation. The climate data were collected from the literature about the four long-term forest ecosystem stations. Soil types belong to FAO/UNESCO.

Table 2

The correlation between soil microbial biomass carbon and influencing factors

factors / correlation / carbon	Forest Type	Soil Type	MAT	MAP	ALT	Slope
MBC (0-20 cm)	-.53**	-.76**	-.70**	-.41**	.53**	-.29**
MBC (20-40 cm)		-.34**	-.34**		.64**	.37**
MBC (40-60 cm)		-.25*	-.22*		.47**	.29**