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Full Length Article

Effects of Long-Term Fertilization on Organic Carbon Mineralization of Different Grain Size Components in Paddy Soils from Yellow Earth

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Abstract

Organic carbon in different soil components shows different fertility and bioavailability because of the difference in its stability. Studying the mineralization difference of organic carbon in soil components under long-term fertilization can provide basis for understanding soil components stability and carbon cycle theory. Organic carbon with different particle size components as an important medium in the formation process of humu, which strength of carbon sequestration capacity directly affects the difference of carbon storage. Therefore, the definition of the stability of different components organic carbon will inevitably enrich the mechanism of organic carbon in the whole soil. In this paper, the mineralization characteristics of coarse particle component (250–2000 μm), microaggregate component (53–250 μm) and clay particles (<53 μm) under different treatment (no fertilization (CK), chemical fertilizer (NPK), organic fertilizer (M) and constant organic-inorganic fertilizer (MNPK)) were studied by indoor simulated culture test, and potential mineralizable organic carbon and turnover rate were calculated using the first-order kinetic equation. The results showed that the content of organic carbon and potential mineralizable organic carbon were the highest in coarse particle components and the lowest in clay particle components under different fertilization treatments. Organic fertilizer treatment (M and MNPK) significantly increased its content. The trend of organic carbon mineralization rate was the same, which can be divided into rapid mineralization on 3—12th day and slow mineralization on 12–30th day. The release intensity of organic carbon accumulation mineralization decreased with the extension of culture time. The cumulative mineralization rate of organic carbon in all soil components decreased more in organic fertilizer treatment than CK treatment, which was 0.47–0.15 percentage points and decreased with the decreasing fraction. Overall results suggested that the effects of different fertilization treatments on soil components were mainly manifested on larger fraction components. Organic fertilizer can be used as a better choice for carbon storage management and the carbon sequestration capacity of different components increases with the decrease of particle size, and this study can provide an important basis for the soil fertility of yellow paddy fields.

Keywords: Long-term fertilization; Yellow paddy soil; Different fractions; Organic carbon mineralization; Fitting parameters

Introduction

Soil organic carbon is the largest and most active carbon pool in the terrestrial ecosystem of the earth (Abdalla *et al.*, 2018). It is estimated that the organic carbon fixed in the global soil is about 1500 Pg, which exceeds the sum of vegetation and atmospheric organic carbon reserves (Zhang *et al.*, 2018). Due to the huge reserves of soil organic carbon, its small changes will affect the emission of carbon into the atmosphere, which in turn affects the composition, structure and distribution of terrestrial ecosystems (Zhao *et al.*, 2006; 2018). Soil organic carbon mineralization is an important biochemical process in soil, which is closely related to soil nutrient release, soil quality maintenance and greenhouse gas formation (Wang *et al.*, 2008). The release of soil organic carbon is an important carbon source for greenhouse gas emissions, while soil organic carbon sequestration plays a carbon sink function for greenhouse gases (Zhou *et al.*, 2008). Organic carbon in different soil fractions, as an intermediate product of humus transformation of animal and plant residues in soil, is a result of synergistic effect of all organisms in soil. Compared with total organic carbon, different components organic carbon are more sensitive to fertilization level, temperature, humidity and land use mode (Haynes *et al.*, 1991). Therefore, increasing organic carbon in different soil fractions is considered as an important way

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to restrain the decomposition of soil organic carbon and mitigate the greenhouse effect (Mikha and Rice, 2004). A comprehensive understanding of the mineralization laws of soil organic carbon in different components is of great significance for the scientific management of soil nutrients and for controlling global warming.

Due to the different nature of the aggregates of different sizes and the different residual amounts and decomposition rates of different organic materials in the soil, there is a certain difference in the response of soil organic carbon to fertilization treatments in all aggregates (Lugato *et al.*, 2010). Li *et al.* (2010) showed that the intensity of CO_2 release by soil organic carbon mineralization concerned the input of organic materials and the content of soil organic carbon. In the study on the response of different fractions to long-term fertilization, Sleutel *et al.* (2006) proposed that the amount of combined organic carbon and the ability of anti-decomposition vary with the surface chemical properties. For the important biogeochemical process of soil organic carbon mineralization, Miao *et al.* (2009) pointed out in the study on mineralization of black soil in Northeast China that long-term use of fertilizers and organic fertilizers can significantly increase the rate of soil organic carbon mineralization and cumulative mineralization amount. Wu *et al.* (2016) also showed that long-term fertilization could increase the cumulative mineralization amount of soil organic carbon, reduce the loss rate of organic carbon per unit mass and increase its carbon fixation. In the study of organic carbon mineralization in soil aggregates, the results of different researchers vary. Wei *et al.* (2011) showed in the study on karst soil aggregates that mineralization rate and cumulative mineralization amount of soil organic carbon increased with the decrease in aggregate particle size. However, the results of Elliott and Cambardella (1991) showed that smaller components are more susceptible to mineralization due to the younger organic carbon in the larger fraction soil components. Liu *et al.* (2016) also showed in the study on response of soil aggregate stability to different land use patterns that the cumulative mineralization rate of organic carbon in soil aggregates increased with decreasing particle size, indicating that larger aggregates are more capable of carbon fixation than smaller aggregates. Taken together, long-term fertilization promoted the mineralization of soil total organic carbon (Miao *et al.*, 2009; Wu *et al.*, 2016), but there was a significant difference in the response of organic carbon mineralization to ecosystem types and land use patterns for different soil components (Elliott and Cambardella, 1991; Wei *et al.*, 2011; Liu *et al.*, 2016).

Guizhou yellow paddy soil is paddy soil after yellow soil undergoes hydroponic development, also known as yellow muddy soil. Its area accounts for 46% of the paddy soil area in Guizhou Province. In addition to rice production, paddy field also has ecological function of fixing atmospheric CO_2 and alleviating the global climate change (DAGP and ISSCAS, 1980). At present, the studies on the effect of long-term fertilization on mineralization of soil organic carbon mostly focus on organic carbon in the whole soil. However, the response of organic carbon mineralization of different components to long-term fertilization has rarely been reported. For yellow paddy soil, whether large-fraction soil organic carbon or small-fraction soil organic carbon is easily mineralized is not well defined. Therefore, this study based on the long-term (22 years) location experiment of yellow soil paddy in Guizhou Academy of Agricultural Sciences, wet sieving, lye absorption and first-order kinetic equation fitting were used to determine and analyze the differences in soil organic carbon content and mineralization amount between different components, clarify dynamic changes of organic carbon mineralization, cumulative mineralization and carbon fixation in yellow paddy soil under different fertilization treatments, to provide reference for further understanding soil organic carbon stabilizing mechanism under long-term fertilization and predicting balance of soil organic carbon pool.

Materials and Methods

Experimental Site Overview

The long-term location experimental site is located in Guizhou Academy of Agricultural Sciences (106°39'52"E, 26°29'49"N). Seated in the hilly area of central Guizhou, it has a subtropical monsoon climate with an average elevation of 1071 m and average annual temperature 15.3ºC. The average annual sunshine duration is about 1354 h and the relative humidity is 75.5%. The annual frost-free period is about 270 days and the annual precipitation is 1100–1200 mm. The soil type of the experimental site is yellow paddy soil, and the parent material is Triassic limestone and sand shale weathering material. The long-term location test began in 1995. For the basic soil samples collected in 1994, the basic compositions of its plough layer (0–20 cm) soil include: organic matter 31.15 g kg^{-1}, total nitrogen 1.76 g kg^{-1}, total phosphorus 2.3 g kg^{-1}, total potassium 13.84 g kg^{-1}, available nitrogen 134.4 mg kg^{-1}, available phosphorus 21.1 mg kg^{-1}, available potassium 157.9 mg kg^{-1}, with pH at 6.6.

Experimental Design

The experiment was carried out with large area contrast test without any repetition. The plot area was 201 m^2 (35.7 × 5.6 m). Four representative fertilization treatments (no fertilization (CK), chemical fertilizer (NPK), organic fertilizer (M) and constant organic-inorganic fertilizer (MNPK)) were selected for the study on the long-term experimental site. The tested fertilizers were urea (including N 46%), superphosphate (including 16% P_2O_5), potassium chloride (including 60% K_2O); the organic fertilizer was cattle manure (including C 413.8 g kg^{-1}, N 2.7 g kg^{-1}, P_2O_5 1.3 g kg^{-1}, K_2O 6.0 g kg^{-1}). Annual application of organic fertilizer is 61.1 t ha^{-1} in M treatment, and N 165 kg ha^{-1}, P_2O_5 82.5 kg ha^{-1}, K_2O

82.5 kg ha^{-1} year according to nutrient content of organic fertilizer. Rice is harvested once a year. Before sowing, fertilizer or organic fertilizer was applied as a base fertilizer in accordance with the experimental program in each treatment. In the growing season, topdressing of urea was carried out twice. The rice is transplanted in April each year and harvested in mid-to-late October, with other times for rest.

Soil Sample Collection

After the rice was harvested in mid-to-late October 2016, the plots were equally divided into 3 sample pieces (67 m^2) to collect surface soil samples in 0–20 cm. Each sample was evenly distributed with spots and 5 spots were collected to form a mixed sample. Three soil samples were collected in each plot as 3 repetitions. The samples were mixed well after removal of animal, plant residues, air-dried indoor, ground and screened with 2 mm diameter sieve for wet sieving grouping.

Soil Organic Carbon Grouping

Wet sieving method was used in grouping (Six *et al.*, 1998). The coarse particle component> 250 μm, microaggregate component 53–250 μm and clay particle component <53 μm were obtained after separation. First, 20 g of soil sample <2 mm was put on top sieve (upper 250 μm, lower 53 μm) of microaggregate separator sieve set, also 30 glass beads with a diameter of 4 mm were placed in and then the device was shaken up and down for about 20 min. The component remaining on the 250 μm sieve was coarse component, that on 53 μm sieve was microaggregate component and that in aqueous solution is free-flowing clay particle component. In the final step, the component <53 μm was centrifuged at 3200 rpm for 15 min to extract clay particle component. All components were evaporated to dryness in a water bath and ground (over 0.25 mm sieve). The organic carbon of each component was determined by $K_2Cr_2O_7$-H_2SO_4 external heating method and the total nitrogen was determined by Kjeldahl method (Wen, 1984).

Mineralization Culture Test

Soil organic carbon mineralization culture adopted lye absorption method (Bao, 2000) 30.0 g of coarse particles, microaggregates and clay particle components were respectively weighed and placed in a 50 mL beaker, adjusted to 60% of field capacity with deionized water, placed in the bottom of a 1000 mL culture flask, and pre-cultured for 7 days in 25°C incubator. Then, the 50 mL absorption cup containing 10 mL of 0.1 mol L^{-1} NaOH solution was placed on the bottom of the flask and incubated in a dark incubator at 25°C after sealing the flask with a lid. Each fertilization treatment repeated 3 times. Three blank controls were set at the same time, there being a total of 39 groups of mineralized culture microsystems. On the 3rd, 6th, 9th, 12th, 15th, 18th, 21st, 24th, 27th and 30th day of culture, the lye absorption cup was replaced and added with water to constant weight. Add 2 mL 1 mol L^{-1} $BaCl_2$ solution, 2 drops of phenolphthalein indicator, followed by titration to colorless with 0.1 mol L^{-1} HCl (calibrated with borax before each titration). The mineralization rate and cumulative mineralization amount of organic carbon in soil components were calculated based on the amount of CO_2 released during the culture period.

Data Analysis

The first-order kinetic equation (Chen *et al.*, 2014) can well reflect the cumulative mineralization process of soil organic carbon:

$$C_t = C_0(1 - e^{-kt})$$

Where C_t is the accumulative mineralization amount of soil after 30 days of indoor incubation, g kg^{-1}; C_0 is potential mineralizable organic carbon of soil, g kg^{-1}; k is the turnover rate constant of the organic carbon pool, d^{-1}; t is the number of cultivation days, d; where half turnover time is computed by the turnover rate constant:

$$T_{1/2} = \ln 2/k$$

Therefore, this equation can be used to fit the cumulative mineralization amount of component organic carbon. The experimental data were analyzed by ANOVA with SPSS 19.0 and the significant difference at 5% level was analyzed by Duncan multiple comparison method. The trend graph of mineralization rate and cumulative mineralization amount was plotted with Excel 2016 and the parameters of kinetics equation were fitted with Origin 9.0.

Results

Organic Carbon Content of Each Soil Component

Table 1 shows that the changes of soil organic carbon content of different fraction components have different responses to different fertilization treatments. In general, the organic carbon content was highest in coarse particle under different fertilization treatments, while the content of organic carbon was higher in organic fertilizer treatment (M and MNPK) among all components. Under organic fertilizer treatment (M and MNPK), organic carbon content of coarse particle, microaggregate and clay particle was increased by 89.7–99.2%, 12.1–24.4% and 31.2–54.9%, respectively compared with CK treatment, and was increased by 89.3–98.8%, 6.6–18.3% and 14.1–34.7%, respectively compared with NPK treatment. The increase was the largest in M treatment with the most significant effect ($P < 0.05$).

Contribution Rate of Each Soil Component Organic Carbon to Total Organic Carbon

From the distribution ratio of organic carbon content of

Table 1: Content of soil organic carbon fractions under long-term fertilization treatments (g kg^{-1})

Treatment	250-2000 μm	53-250 μm	< 53 μm
CK	11.02 ± 0.54 b	8.93 ± 0.36 b	5.41 ± 0.25 c
NPK	11.04 ± 0.27 b	9.39 ± 0.56 b	6.22 ± 0.34 bc
M	21.95 ± 0.08 a	11.11 ± 0.36 a	8.38 ± 0.32 a
MNPK	20.90 ± 0.44 a	10.01 ± 0.33 ab	7.10 ± 0.99 b

Mean ± standard deviation were shown. Values sharing same letters differ non-significantly (P > 0.05)

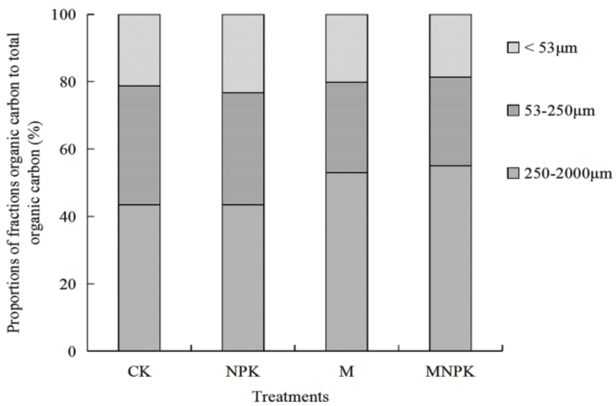

Fig. 1: Proportions of fractions organic carbon to total organic carbon under long-term fertilizations

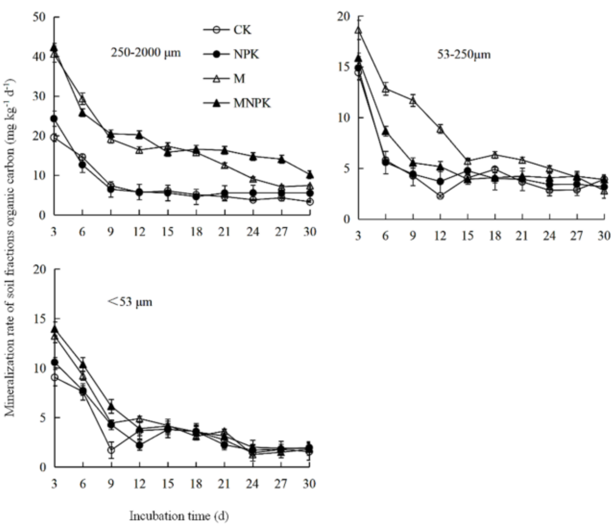

Fig. 2: Mineralization rate of soil fractions organic carbon under long-term fertilization

different components, the ratio of coarse particle organic carbon to total organic carbon was the highest in all fertilization treatments, which was 43.5–55.0%, followed by the microaggregate organic carbon, which accounts for 26.3–35.2%, the ratio of clay particle organic carbon to total organic carbon was the smallest, which was 18.7–23.3% (Fig. 1). There was no significant difference in the proportion of soil organic carbon partitions between NPK treatment and CK treatment. The ratio of coarse particle organic carbon in M treatment and MNPK treatment was significantly increased by 9.5 and 11.5 percentage points compared with CK treatment, and the proportion of microaggregates organic carbon was significantly reduced by 8.4 and 8.9 percentage points, while the proportion of clay particle organic carbon was not significant difference.

Organic Carbon Mineralization Rate of Each Soil Component

Fig. 2 shows that the organic carbon mineralization rates of various soil components under different fertilization treatments have consistent dynamic changes with incubation time. The CO_2 production rate of each component peaked at the beginning of culture (day 3), then decreased rapidly with the prolongation of culture time, and then slowly decreased to steady state after 12 days of culture. Therefore, the whole culture period can be divided into two obvious stages, that is, the early stage of culture on the 3rd–12th day, during which, CO_2 production rate is fast and variation range is large; the later stage of culture on the 12–30th day, during which, CO_2 production rate is slow, and mineralization rates of organic carbon in different soil fractions were almost the same under different fertilization treatments with the extension of incubation time. Organic carbon mineralization rates were significantly different among the three soil components, which were in the ranking of coarse particle organic carbon > microaggregate organic carbon > clay particle organic carbon.

Cumulative Mineralization Amount of Organic Carbon in Each Soil Component

Fig. 3 shows that cumulative mineralization amount of organic carbon in all components is higher in fertilization treatment than that without fertilization treatment. The cumulative release amount of CO_2 shows an upward trend with the incubation time, but the release intensity decreases gradually. At the end of the 30th day, the cumulative mineralization amount of organic carbon in each component was in the order of coarse particle organic carbon (0.59 g kg^{-1}) > microaggregate organic carbon (0.23 g kg^{-1}) > clay particle organic carbon (0.17 g kg^{-1}). Compared with CK treatment, NPK treatment increased the cumulative mineralization amount of organic carbon in each component which, however, did not reach significant difference (P>0.05). The cumulative mineralization amounts of organic carbon in M and MNPK treated groups were similar, which were between 0.56–0.59 g kg^{-1} (coarse particle), 0.17–0.23 g kg^{-1} (microaggregate) and 0.16–0.17 g kg^{-1} (clay particle), increased by 154.5–168.2%, 13.3–53.3% and 33.3–41.7%, respectively compared to CK treatment. The cumulative mineralization amount of coarse particle organic carbon and microaggregate organic carbon was not only significantly higher than that of CK, but also had significant difference compared with NPK treatment (P < 0.05).

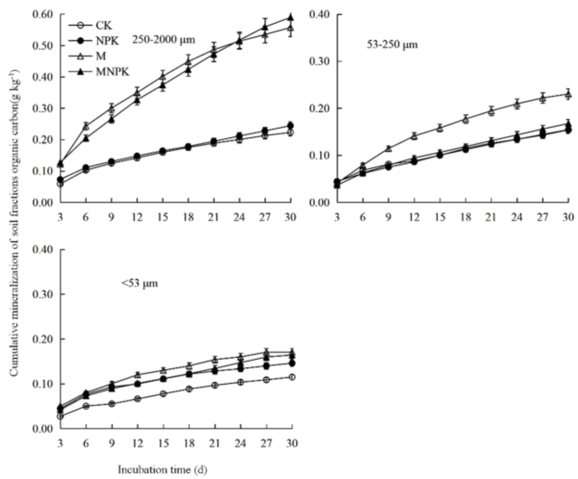

Fig. 3: Cumulative mineralization of soil fractions organic carbon under long-term fertilization

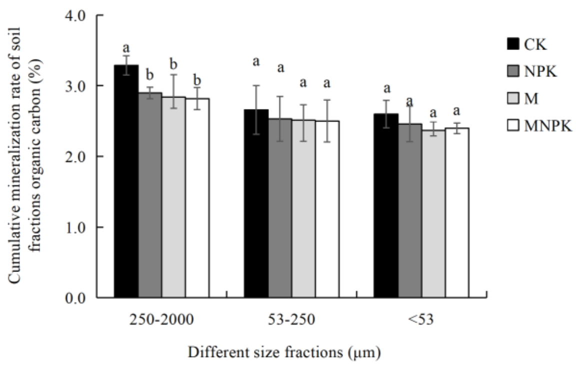

Fig. 4: Cumulative mineralization rate of soil fractions organic carbon under long-term fertilization

However, there was no significant difference (P > 0.05) in the cumulative mineralization amount of organic carbon in clay particle.

Cumulative Mineralization Rate of Organic Carbon in Each Soil Component

Fig. 4 shows the distribution characteristics of cumulative mineralization rate of organic carbon in each soil component under different fertilization treatments after 30 days of indoor incubation. Compared with CK treatment, fertilization treatment decreased the cumulative mineralization rate of organic carbon in each component. Only the organic carbon in coarse particles reached a significant difference (P < 0.05), and the cumulative mineralization rate of organic carbon in coarse particle > that in microaggregate > that in clay particle. Compared with CK treatment (3.3–2.6%), the cumulative mineralization rate of organic carbon in soil components decreased by 0.39–0.13 and 0.47–0.15 percentage points in turn in NPK and organic fertilizer treatments (M and

Table 2: The kinetic equation parameters for mineralization of soil organic carbon fractions

Different size (μm)	Treatment	C_0 (g kg-1)	k (d^{-1})	$T_{1/2}$ (d)	R^2
250-2000	CK	0.23b	0.070a	9.9a	0.976**
	NPK	0.26b	0.072a	9.6a	0.934**
	M	0.62a	0.076a	9.1a	0.991**
	MNPK	0.77a	0.077a	9.0a	0.991**
53-250	CK	0.17b	0.053b	13.1a	0.928**
	NPK	0.17b	0.055ab	12.8ab	0.938**
	M	0.29a	0.064a	10.8b	0.995**
	MNPK	0.20b	0.058ab	12.0ab	0.977**
<53	CK	0.13c	0.067b	10.6a	0.977**
	NPK	0.15bc	0.080ab	8.6ab	0.970**
	M	0.18ab	0.092a	7.6b	0.986**
	MNPK	0.21a	0.079ab	8.9ab	0.966**

Values sharing same letters differ non-significantly (P > 0.05). ** mean significant correlation at the 1% levels(P < 0.01)

MNPK). It indirectly shows that different fertilization treatments have different degrees of fixation effect on soil organic carbon. The carbon fixation effect increases with the decrease of fraction, and the application effect of organic fertilizer is superior to that of chemical fertilizers.

Kinetic Equation Parameters of Organic Carbon Mineralization in Each Soil Component

Table 2 shows that under long-term different fertilization treatments, the dynamic changes of cumulative mineralization amount of organic carbon in soil components with the number of cultivation days can be fitted with the first-order kinetic equation. The determination coefficients are all highly significantly correlated at 1% level, indicating that the first-order kinetic equation can better describe the dynamic changes of cumulative mineralization amount of organic carbon in each component. Generally speaking, the potential mineralizable organic carbon (C_0) of each component is higher in organic fertilizer treatment (M and MNPK). That in M treatment increased significantly by 169.6–38.5% (P < 0.05) compared with CK treatment (0.23–0.13 g kg^{-1}). The largest increase of coarse particle and the decrease of C_0 value with the decreasing fraction were observed. However, NPK treatment had no significant difference (P > 0.05) compared with CK treatment. The turnover rate (k) and half-turnover time ($T_{1/2}$) of the organic carbon pool also varied under different fertilization treatments, with k value in the range of 0.053–0.092 d^{-1} and $T_{1/2}$ in the range of 13.1–7.6 d. There was no significant difference in coarse particle organic carbon between the fertilization treatments, and obvious differences were observed in microaggregate organic carbon and clay particle organic carbon between M and CK treatments. In different fertilization treatments, the turnover rate of organic carbon in each component was the best in organic fertilizer treatment, followed by chemical fertilizer, and the rate was the lowest in non-fertilization treatment, while half-turnover time has the opposite result, indicating that organic fertilizer can effectively increase potential mineralizable organic carbon in coarse particles, shorten the organic carbon turnover time of each component and speed up the turnover rate.

Discussion

The results of this study showed that after long-term different fertilization treatments, coarse particle organic carbon had the largest increase among different components, which may be due to cementation of organic matter that promoted the combination of soil fine particles and small aggregates to form large aggregates, making organic carbon content of coarse particles relatively high, consistent with the results of Jastrow *et al.* (1996) and Huang *et al.* (2009). In this study, M and MNPK treatments significantly increased soil organic carbon content in each fraction and the contribution of coarse particle organic carbon to soil total organic carbon, indicating that M and MNPK treatments had a better effect on organic carbon accumulation than NPK treatment. The reason may be that organic fertilizer C/N ratio is low, nitrogen is sufficient and easy to be decomposed by microorganisms. It may also because organic fertilizer increases the content of soil organic carbon cement, improves soil aggregate structure, and then its package action provides physical protection to soil organic carbon so that microbial contact and decomposition is avoided (Tripathi *et al.*, 2014; Shahid *et al.*, 2017). In addition, the proportion of microaggregate organic carbon and clay particle organic carbon to total soil organic carbon decreased under organic fertilizer treatment, which may be due to the increase of the number of soil fungi in coarse particle organic carbon after organic fertilizer treatment (Haynes *et al.*, 1991), which causes the conversion of clay particle and microaggregate organic carbon into coarse particle organic carbon under the action of fungal hyphae (Xie *et al.*, 2017). Plus, the organic carbon content in clay particle increased by microbial metabolic secretions is smaller than the organic carbon amount transferred from clay particle to coarse particle.

In this study, the organic carbon mineralization rate in each component showed a rapid decline from the peak at the beginning of culture, and then slowly decreased to a stable phase with the extension of incubation time, which is consistent with the results of Xie *et al.* (2017). This is because organic carbon of each component is composed of active and inert parts. The active part is rapidly decomposed and utilized by the soil microorganism in the early stage of culture, so the mineralization rate declines rapidly. Nevertheless, the inert part is difficult to be utilized by the microorganism in the late stage of cultivation, so the mineralization rate is stable (Wei *et al.*, 2011; Liu *et al.*, 2016). The cumulative mineralization amount of organic carbon in each soil component had consistent change trend with mineralization rate, which was first quick and later slow and the amount decreased with the decreasing particle size under different fertilization treatments. It indicates that large particle size components in yellow paddy soil are not conducive to the accumulation of organic carbon. The clay particles have relatively stable organic carbon content, which may be related to soil organic carbon content and microbial biomass in soil components. Sato and Seto (1999) found that potential mineralizable organic carbon in soil is related to soil total organic carbon and soil microbial biomass carbon.

In this experiment, the mineralization rate and cumulative mineralization amount of soil organic carbon are higher in fertilization treatment than those without fertilization treatment, and organic fertilizer is generally superior to chemical fertilizer in effect. It may be because application of organic fertilizer directly promotes the increase of activated carbon source and enhances the activity of microorganisms and extracellular enzymes of soil components, thereby promoting the decomposition of soil organic carbon components and producing positive excitation effect (Kuzyakov *et al.*, 2000; Wei *et al.*, 2016). There was no significant difference in soil organic carbon mineralization rate and cumulative mineralization amount of each component between long-term application of chemical fertilizers and no fertilization.

The strength of soil carbon fixation can be expressed by the cumulative mineralization rate of organic carbon. The lower the proportion is, the stronger the soil carbon fixation is, otherwise the weaker (Mikha and Rice, 2014). In this study, the cumulative mineralization rate was the highest in coarse particle organic carbon under different fertilization treatments, and the lowest in clay particle organic carbon, which was consistent with the mineralization rate and cumulative mineralization amount of organic carbon in components, indicating that the absolute mineralization amount (mineralization level of unit organic carbon) of organic carbon is relatively high in coarse particle of yellow paddy soil under long-term fertilization, the relative stability is poor, while the clay particles are more protective of organic carbon. All fertilization treatments decreased the cumulative mineralization rate of organic carbon in the components as compared with no fertilization treatment because long-term treatment of NPK and organic fertilizers increased the contents of nitrate nitrogen and ammonium nitrogen in soil components, which produced chemical reactions with lignin residue and Phenolic compounds, so that the decomposability of organic carbon in components decreased (Jenkinson *et al.*, 1985; Duan, 2001; Wu *et al.*, 2017).

In this study, different fertilization treatments had different effects on potential mineralizable carbon (C_0), turnover rate constant (k) and half turnover time ($T_{1/2}$) of the soil components. In overall, organic fertilizer effectively increased C_0 value of each component, probably because the number of soil culturable microorganisms in this treatment was significantly higher than that in other treatments, or extracellular enzyme of each fraction component increased significantly (Wei *et al.*, 2016). The results of this study showed that single organic fertilizer treatment significantly increased the k value of organic carbon in microaggregate and clay particle, the half turnover time $T_{1/2}$ also decreased significantly, while the k value of coarse particle organic carbon had no significant difference among the treatments, which may be because long-term fertilization affects various soil properties (Ghosh *et al.*, 2016). However, to reveal its mechanism in depth, it is necessary to maintain the original status of all fraction soil components (indoor analysis excludes the effect of external environment), and based on this, conduct further study on species and amount of microbial communities between the components.

Conclusion

The contents of soil organic carbon and potential mineralizable organic carbon varied widely in different fertilizer treatments, but their differences and contents decreased with the decreasing fraction, indicating that the effects of different fertilization treatments on soil components are mainly manifested on formation and stability of larger fraction components. Among the components with different fractions, the mineralization rate and cumulative mineralization amount of organic carbon in each treatment were in the order of organic fertilizer (M and MNPK) > single fertilizer (NPK) > no fertilization (CK). The mineralization rate of organic carbon in all fraction components can be divided into two stages: rapid mineralization and slow mineralization. The variation is basically the same. The cumulative mineralization rate of organic carbon decreases with the decreasing fraction, and small fraction components are more capable of carbon fixation than larger fraction components. The results indirectly indicated the carbon sequestration capacity of different components, which provides a theoretical basis for predicting future global greenhouse gas emission trends and the establishment of carbon sequestration models. The response of organic carbon mineralization to different fertilization measures is of great significance for realizing the reuse of agricultural resources and maximizing their benefits. Although the research has achieved certain research results, we only studied the effects of fertilization measures on the organic carbon mineralization in the yellow paddy fields, and did not involve other environmental factors. The effect of other environmental factors (such as moisture and temperature) on soil organic carbon mineralization is a problem that needs further study. For the study, the response mechanism of organic carbon mineralization to external environmental factors can be raised to the molecular level to study the effects of external factors on soil organic carbon mineralization through the changes of soil microbial function and community diversity.

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