

SEASONAL VARIATION OF MICROBIAL BIOMASS C AND SOIL RESPIRATION IN RICE PADDIES IN BLACK EARTH AND CORRELATION BETWEEN THEM AND CH₄ EMISSION

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ABSTRACT

Microbial biomass C, soil respiration and CH₄ emissions were measured during the whole rice growth period in rice paddies in black earth. The results showed microbial biomass C and soil respiration were depressed significantly by application of slow-releasing urea at the early stage of rice growth period ($P < 0.05$), but were almost not affected by intermittent irrigation . CH₄ emission, on the average, was reduced by 32.5% in the intermittent irrigation treatments, compared to the control. But CH₄ emission was, in the general, not significantly affected by application of slow-releasing urea. CH₄ emission was significantly related to microbial biomass C in slow-releasing urea treatments.

Key words black earth CH₄ emission microbial biomass
soil respiration

1.0 INTRODUCTION

CH₄ is one of the most important greenhouse gases. Although the concentration of CH₄ in the atmosphere is much lower than CO₂, it is 23

times more effective per molecule than CO₂ as a greenhouse gas (IPCC, 2001). Rice paddies are a significant source of atmospheric CH₄, and methane emission from flooded rice fields contributes up to 12% of global CH₄ emission to the atmosphere (IPCC, 1992). In recent years, related studies on CH₄ emission from rice paddies are more, most of which are about the effect of soil properties, temperature, fertilizer management, irrigation and rice cultivars on the CH₄ emission.

Organic carbon is important component of soil organic matter. The effective carbon pool of soil plays a key role in modulating carbon element and nutrient flow, whereas static carbon pool only affects soil properties (Blair et al. 1995, Loginow et al. 1987). Microbial biomass C and CO₂ emitted from soil respiration belong to effective carbon pool in soil. And they are easily mobilized and often vary. Since the relationship between this part of active organic carbon and CH₄ emission is not very clear now, this article will try to discuss it, especially the relationship between microbial biomass C and CH₄ emission.

2.0 MATERIALS AND METHODS

2.1 STUDY SITES AND SOIL DESCRIPTION

The field experiment was conducted at Hailun Experimental Station of Ecology in Hei Longjiang Province (47°26'N , 126°38'E) in 2000. The soil type is black earth with 48.2g Kg⁻¹ of organic matters, 2.2g Kg⁻¹

of total-N, 7.02 of pH value.

Three similar plots were chosen (the size of each one was 0.07ha). Different water management and fertilization were adopted in the three plots, with continuous irrigation, slow-releasing urea (A field), continuous irrigation, urea (control: B field), intermittent irrigation, urea(C field), respectively.

Rice transplanting was on 28 May, and rice was harvested on 30 September. Field drying was conducted twice, 3 June to 13 June and 1 August to 8 August. The fields were drained completely on 28 August.

Slow-releasing urea as basal fertilizers with $95.4 \text{ Kg N ha}^{-1}$ were all incorporated into soil on 20 May, the same time as the first incorporation of urea as basal fertilizers. Split application of the remaining urea was conducted on 7 June and 23 June, respectively. The slow-releasing urea and urea were both provided by SKW company in Germany.

2.2 SAMPLING AND MEASUREMENTS

2.2.1 CH₄ SAMPLING AND ANALYSIS

CH₄ fluxes were measured once a week throughout the growing season using a closed chamber method. Methane concentrations were determined with GC-14B gas chromatograph (SHIMADZU) equipped with a FID detector. The column temperature was set at 100°C and the injector and detector at 100°C and 200°C, respectively. Standard gas of CH₄ was provided by National Research Institute of Standard Material,

China.

2.1.2 MEASUREMENTS OF SOIL RESPIRATION AND MICROBIAL BIOMASS C

The soil was taken from 5 cm layer of the experimental plots and was stored in the 4° refrigerator. In a week the analysis of soil respiration and extraction of microbial biomass C would be completed.

Soil respiration was measured by closed incubation method. Microbial biomass C in the soil was determined by the chloroform-fumigation-K₂SO₄ extraction method (Lu, 2000).

2.1.3 STATISTICAL ANALYSIS

The data were analyzed by using SPSS 10.0 software.

3. RESULTS AND DISCUSSION

3.1 SEASONAL VARIATION OF MICROBIAL BIOMASS-C DURING RICE GROWTH PERIOD

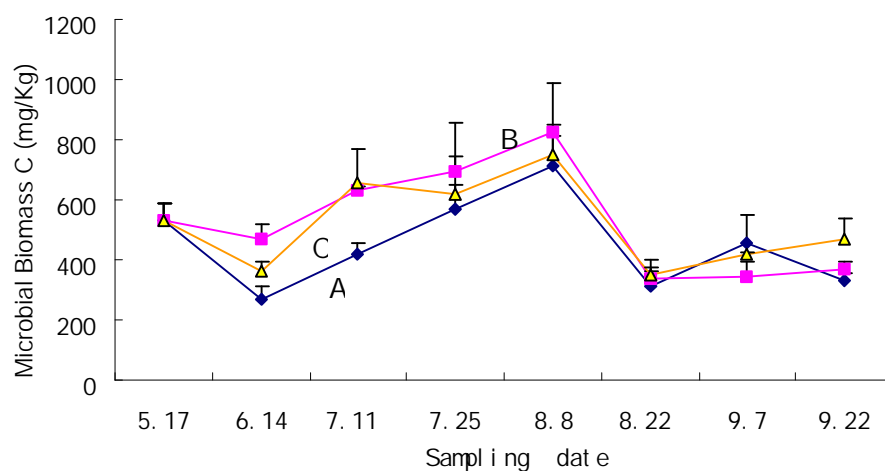


Fig.1 seasonal variation of microbial biomass C during rice growth period

- A. treatment of slow-releasing urea ? continuous irrigation
- B. treatment of urea? continuous irrigation
- C. treatment of urea? intermittent irrigation

As shown in Fig. 1, microbial biomass-C in soil of these three treatments all firstly increased, and then decreased with the growth of rice. Microbial biomass-C decreased at the early stage of rice growth by possible reason of harrowing before transplanting (Garcia and Rice, 1994). Following increase of microbial biomass-C were attributed to mineralization of soil organic matter which were promoted by more and more root exudation and high temperature with the growth of rice. After reaching maximum, microbial biomass-C began to decrease and to the original level until harvest. This result was the same as previous research (Franzlubbers et al. 1994).

After maximum, microbial biomass-C of the three treatment (A, B, C) increased by 35%?56%?42%, respectively, compared to early stage of rice. Microbial biomass-C in the treatment of slow-releasing urea increased slower than the other two. Maybe the use of slow-releasing urea depressed the metabolism of microbe growth in soil. Using One-Way ANOVA and Multiple Comparisons to analyse the data, the difference of microbial biomass-C between treatment A and B was significantly on 14 June and 11 July (14 June: $P=0.01<0.05$; 11 July: $P=0.018<0.05$). According to the results above, we could conclude that slow-releasing

urea indeed could depress the microbial biomass-C at the early stage of rice growth. DCD (ammonium bicarbonate co-crystallized with dicyandiamide) of slow-releasing urea maybe depress the activity of microbe in soil, and lower the efficiency of microbe utilizing decomposable carbon source to compose necessary organic matter.

Data analysis proved the difference between intermittent irrigation and control was not significantly ($p>0.05$). Although previous studies showed drying-wetting cycle could stimulate the change of microbial biomass, intermittent irrigation didn't affect microbial biomass-C basally in this experiment.

3.2 SEASONAL VARIATION OF SOIL RESPIRATION DURING RICE GROWTH PERIOD

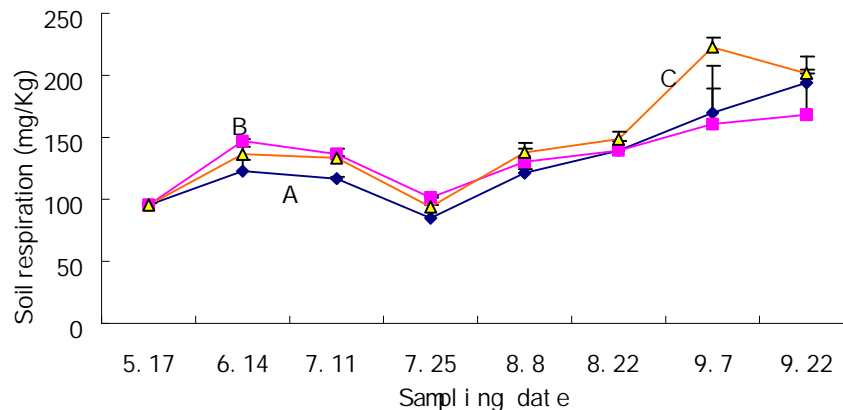


Fig.2 seasonal variation of soil respiration during rice growth period

- A. treatment of slow-releasing urea ? continuous irrigation
- B. treatment of urea? continuous irrigation
- C. treatment of urea? intermittent irrigation

As shown in Fig 2, the variation of soil respiration of three treatments were basically similar, all increasing at the early stage, then a little decreasing, and gradually increasing until the harvest. At the early stage, soil respiration increased perhaps due to the enhancement of microbial activity in soil. In June, as it grows warmer, microbe in soil was more active, and more and more decomposable organic matter from root exudation accumulated in soil which provided abundant substrate available to microbe so as to increase the soil respiration. This result was the same as the related study in grass (Yang et al, 1989). Excluding the late July, the soil respiration decreased with unclear reason. Up to August, the soil respiration increased all through the remaining rice growth period. Especially at the late stage, soil respiration still increased after drainage maybe due to soil water content change (Kucera and Kirkham, 1971, Tesarova and Gloser, 1976). When the fields were flooded, the water content was very high nearly to saturation condition and anaerobic microbe was active, whereas aerobic microbe being depressed. After drainage, soil aeration was enhanced, aerobic microbe began to be active, additionally, and the temperature was still high. These all stimulated soil respiration.

The increase of soil respiration in the treatment of slow-releasing urea was slower than the control (B field). Data analysis proved the difference of soil respiration between A and B was significantly on 14 June, 11 July and 25 July (6.14: $P=0.003<0.05$; 7.11: $P=0.000<0.05$; 7.25: $P=0.034<0.05$). It could be concluded that slow-releasing urea depressed the soil respiration at the early stage of rice growth. Nitrification inhibitor- DCD inhibit the activity of nitrification related microbe so as to reduce the activity of the whole microbe in soil. The soil respiration would be decreased with the reduction above.

Statistical analysis results showed the intermittent irrigation didn't

affect soil respiration evidently, despite the significant effect of water content on soil respiration (Kucera and Kirkham, 1971, Tesarova and Gloser, 1976). Maybe the variation of soil respiration lagged behind the change of water content, that is the changes not simultaneous.

3.3 CH₄ EMISSION AND CORRELATION WITH MICROBIAL BIOMASS-C

CH₄ is produced by obligate anaerobic microorganism. CH₄ production is strongly dependent on inherent soil organic C, fertilizers incorporated, exudation of plants, and so on.

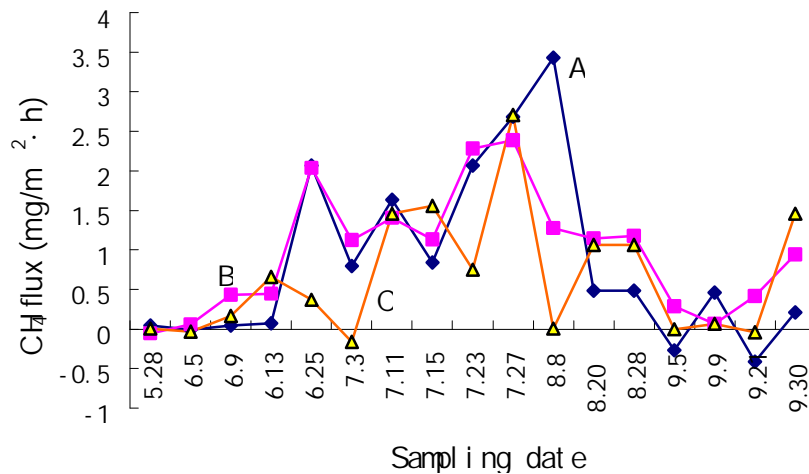


Fig.3 variation of CH₄ flux during rice growth period

- A. treatment of slow-releasing urea ? continuous irrigation
- B. treatment of urea? continuous irrigation
- C. treatment of urea? intermittent irrigation

As shown in Fig. 3, twice drainage during rice growth period had strong effect on the CH₄ emission in the treatment of intermittent irrigation. During the two stages, CH₄ emission was significantly reduced, almost to zero. CH₄ emission of intermittent irrigation treatment (C field)

was depressed by 32.5%, on the average, compared to the control (B field). Whereas CH₄ emission of slow-releasing urea treatment (A field) was enhanced by 15% (comparative small), compared to the control. As a result, slow-releasing urea had almost no effect on the CH₄ emission during the whole rice growth period.

Table 1 correlation between CH₄ flux and microbial carbon in slow-releasing urea treatment

	microbial carbon	CH ₄ flux
microbial carbon Pearson Correlation	1.000	.794*
Sig. (2-tailed)	.	.019
N	8	8
CH ₄ flux Pearson Correlation	.794	1.000
Sig. (2-tailed)	.019	.
N	8	8

Correlation is significant at the 0.05 level (2-tailed).

Microbial biomass-C is relative active organic C in soil. And it is effective organic matter for microbe growth. The amount of microbial biomass-C indirectly reflects the activity of microbe that will affect the emission of greenhouse gas. Statistical analysis showed that CH₄ fluxes were significantly correlated with microbial biomass-C in the treatment of slow-releasing urea, not in the other two treatments. So, in general, the

relationship between CH₄ fluxes and microbial biomass-C was not significant in rice paddies.

The results above suggest that microbial biomass-C was not a critical factor in CH₄ emission in rice paddies in this study, although it could reflect the activity of microbe in some degree. So it is necessary to study CH₄ emission from other aspects so as to get more and deep information.

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