

Research Article



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## 온도상승 환경 처리가 논토양과 용수에서 탄소량 변화와 벼 생육에 미치는 영향

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### Elevated Temperature Treatment Induced Rice Growth and Changes of Carbon Content in Paddy Water and Soil

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#### Abstract

**BACKGROUND:** The global mean surface temperature change for the period of 2016~2035 relative to 1986~2005 is similar for the four representative concentration pathway (RCP)'s and will likely be in the range of 0.3°C to 0.7°C. Climate change inducing higher temperature could affect not only crop growth and yield, but also dynamics of carbon in paddy field.

**METHODS AND RESULTS:** This study was conducted to evaluate the effect of elevated temperature on the carbon dynamics in paddy soil and rice growth. In order to control the elevated temperatures, the experiments were set up as the small scale rectangular open top chambers (OTCs) of 1 m (width)×1 m (depth)×1 m (height) (Type 1), 1 m (W)×1 m (D)×1.2 m (H) (Type 2), and 1 m (W)×1 m (D)×1.4 m (H) (Type 3). The average temperatures of Type 1, Type 2, and Type 3 from July 15 to October 30 were higher than the ambient temperatures at 0.4°C, 0.5°C, and 0.9°C, respectively. For the experiment, Wagner's pots (1/2,000 area) were placed inside chambers. The pots were filled with loamy soil, and chemical fertilizer and organic

compost were applied as recommended after soil test. The pots were flooded with agricultural water and rice (Shindongjin-byeo) was planted. It was observed that TOC (total organic carbon) of the water increased by the elevated temperatures and the trend continued until the late growth stage of the rice. Soil TOC contents were reduced by the elevated temperatures. C/N ratios of the rice plant decreased by the elevated temperature treatments. Thus, it was assumed that the elevated temperatures induced to decompose soil organic matter. Elevated temperatures significantly increased the culm length ( $P<0.01$ ) and culm weight ( $P<0.05$ ) of rice, but the number and weight of rice panicle did not showed significant differences.

**CONCLUSION:** Based on the results, it was suggested that the elevated temperatures had an effect on changes of soil and water carbons under the possible future climate change environment.

**Key words:** Climate change, Elevated temperature, Open-top chamber, Rice, TOC

#### 서론

1986      2005      2016      2035  
4 가 RCP (      )  
, 0.3°C      0.7°C      가  
가      . 1850      1900      , 2081

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2100 RCP 4.5, RCP 6.0, RCP 8.5  
 1.5°C 가 (IPCC.  
 2014). 가  
 가  
 (Cross and Zuber, 1972; Yan and Hunt,  
 1999).  
 TOC (Total Organic Carbon)  
 (Urban *et al.*, 1989; Hope *et al.*, 1994; Hinton *et al.*, 1997; Agren *et al.*, 2008). TOC  
 1 TOC  
 (Kohler *et al.*, 2008).  
 가 CO<sub>2</sub>  
 가 (Ringius, 2002).  
 가  
 (Townsend *et al.*, 1997).  
 C가 가  
 (Blanco-Canqui and Lal,  
 2004; Trumbore, 2009).  
 (Mathieu *et al.*, 2015),  
 가 (Hobley  
 and Wilson, 2016; White *et al.*, 2009).  
 (Conant *et al.*  
*et al.*, 2011).  
 (Conant *et al.*,  
 2011; Davidson and Janssens, 2006).  
 CO<sub>2</sub> 가  
 CO<sub>2</sub>  
 C/N (Novotny  
*et al.*, 2007; Dray *et al.*, 2014)  
 (Novotny *et al.*, 2007; Huang *et al.*, 2012).  
 C/N  
 3.3  
 (Lal, 2004). 가  
 CO<sub>2</sub>  
 (Subke *et al.*, 2006).  
 Peng (2004) 1992 2003  
 (IRRI)  
 가 1°C 10%  
 (Kobata & Uemuki, 2004).

**재료 및 방법**

**상승온도 처리**

2015 2016  
 가  
 1 m (W)×1 m (D)×1 m (H)  
 (Type 1), 1 m (W)×1 m (D)×1.2 m (H) (Type 2), 1m (W)  
 ×1 m (D)×1.5 m (H) (Type 3)  
 (ambient),  
 1 +0.4°C (ambient+0.4°C), 2  
 +0.5°C (ambient+0.5°C), 3 +0.9°C (ambient+  
 0.9°C)  
 2015 7 1 10 13  
 3 4  
 30  
 가  
 1/2,000 10a 2015  
 4 25 10 5  
 20 5 30 3  
 1  
 ( , 2001)

**시료채취 및 분석**

pH  
 EC pH meter (Model 720A, Orion) EC  
 meter (Model 145A, Orion)  
 (NIAST, 2000). Tyurin  
 ( , 2010), Lancaster ( , 2010)  
 1N NH<sub>4</sub>OAc (pH 7)  
 ICP-OES (GBC Integra XMP, Australia)  
 (NIAST, 2000).  
 TOC ( ) TOC 95  
 0°C WO<sub>3</sub> (Vario  
 TOC cube, Elementar)  
 TOC 2M HCl inorganic carbon  
 C/N  
 CN (Vario MAX CN, Elementar)

Table 1

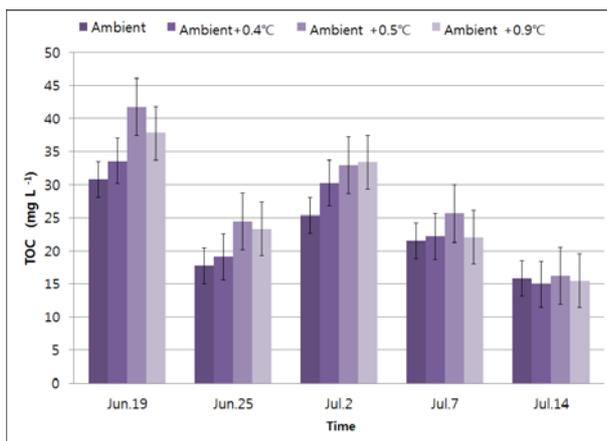
가

**Table 1. Chemical properties of soil used in this study**

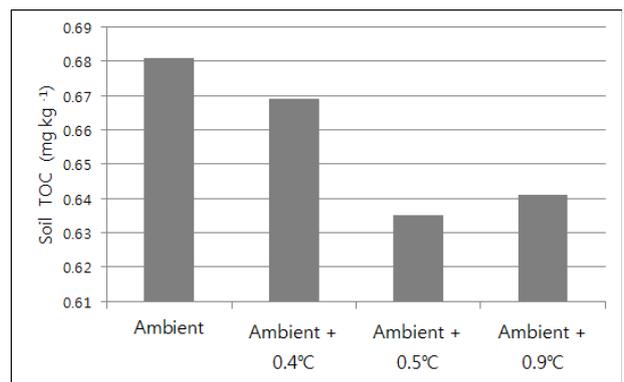
pH (1:5)	EC (dSm)	Organic Matter (g kg <sup>-1</sup> )	Available P <sub>2</sub> O <sub>5</sub> (mg/kg <sup>-1</sup> )	Exchangeable Cations (Cmol kg <sup>-1</sup> )		
				K	Ca	Mg
6.2	0.65	10.0	75	0.61	5.57	1.8

**Table 2. Temperature distribution of small scale rectangular open-top chamber from July 1 to October 13, 2015**

Temperature	Ambient	Ambient+0.4°C	Ambient+0.5°C	Ambient+0.9°C
Average Temperature	23.0°C	23.4°C	23.5°C	23.9°C
Maximum Temperature	29.4°C	32.6°C	33.1°C	33.4°C
Minimum Temperature	17.7°C	17.7°C	16.4°C	17.0°C



**Fig. 1. Changes of total organic carbon (TOC) concentration in Wagner pot's surface water to up-regulated three different air temperature under the open-top chamber. Bars on the each column represent standard errors.**



**Fig. 2. Content of soil total organic carbon (TOC) affected by up-regulated three different air temperature in the open-top chamber.**

**결과 및 고찰**

**사각챔버의 온도분포 특성**

7 1 10 13  
 Table 2  
 23°C , +0.4°C  
 (ambient+0.4°C) 0.4°C가 23.4°C  
 +0.5°C (ambient+0.5°C) 0.5°C  
 23.5°C , +0.9°C (ambient+0.9°C)  
 0.9°C 23.9°C  
 가 29.4°C +0.9°C  
 (ambient+0.9°C) 33.4°C  
 가 17.7°C +0.5°C (ambient+0.5°C)  
 가 16.4°C, +0.9°C (ambient+0.9°C)  
 가 17.0°C  
 2015 5 20  
 5 30 6 19  
 TOC

**Fig. 1**

TOC 6 19 +0.4°C (ambient  
 +0.4°C), +0.5°C (ambient+0.5°C), +0.9°C  
 (ambient+0.9°C) ambient . 6  
 25 7 2 TOC 6 19

7 7 TOC  
 TOC 가 가 7 14  
 TOC +0.4°C (ambient+0.4°C),  
 +0.5°C (ambient+0.5°C), +0.9°C (ambient+0.9°C)  
 (ambient)

TOC  
 Fig. 2 . TOC  
 (ambient) + 0.4°C  
 (ambient+0.4°C), +0.5°C (ambient+0.5°C),  
 +0.9°C (ambient+0.9°C)  
 가

**Fig. 2**

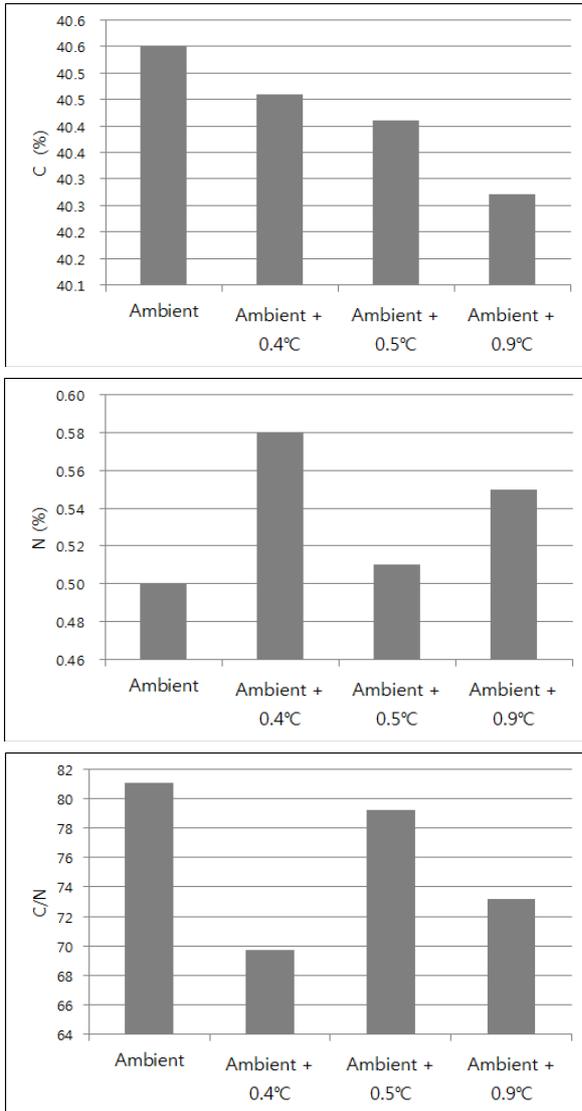


Fig. 3. C/N ratio of rice plant affected by three different elevated air temperature.

가  
가  
Fig. 3  
C/N  
(ambient) 가 40.6% +0.9°C (ambient +0.9°C) 40.3  
(ambient) 가 0.5% +0.9°C (ambient+0.9°C) 0.55%  
가  
C/N 가 81  
+0.9°C (ambient+0.9°C) 73  
CO<sub>2</sub>  
C/N (Novotny *et al.*, 2007; Dray *et al.*, 2014)  
(Novotny *et al.*, 2007; Huang *et al.*, 2012)  
CO<sub>2</sub> 가 C/N  
C/N 가 C/N 가  
C/N  
CO<sub>2</sub> 가  
가  
Table 3  
(P<001), (P<0.05) (LSD) 가  
가  
가

Fig. 1

TOC

TOC

, Suzuki (1980)

가

1

Table 3. Rice yield and yield component affected by elevated temperatures

Treatment	Culm length (cm)	Culm weight (g)	No. of panicles per plant	No. of spikelets per panicle	Percent ripened grain (%)	1000 grain weight (g)	Grain weight (g/plant)
Ambient	63.2	71.1	26.7	104.6	83.0	30.6	70.9
Ambient+0.4°C	66.5	80.7	28.7	97.7	78.5	30.4	67.2
Ambient+0.5°C	69.7	86.0	29.0	100.8	81.1	30.4	72.1
Ambient+0.9°C	71.2	85.5	29.3	99.0	82.8	30.9	74.0
LSD	***(2.57)	**(7.67)	ns	ns	ns	ns	ns

LSD : Least Significant Differences \*\*\*: P<0.01, \*\*: P<0.05

가  
가  
가  
가  
가  
(Prasad *et al.*, 2006; Yoshida *et al.*, 1981; Jagadish *et al.*, 2007).

0.4°C, 0.5°C, 0.9°C  
가 3.2°C, 3.7°C, 4.0°C

가 0.7  
~1.3°C

## 요 약

0.4°C, 0.5°C, 0.9°C

TOC

TOC

C/N

가

가

## Notes

The author declare no conflict of interest.

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