耶鲁大学–南京信息工程大学大气环境中心
Yale-NUIST Center on Atmospheric Environment

Effects of enhanced UV-B radiation on soil respiration and N_2O flux in soybean and winter wheat farmland

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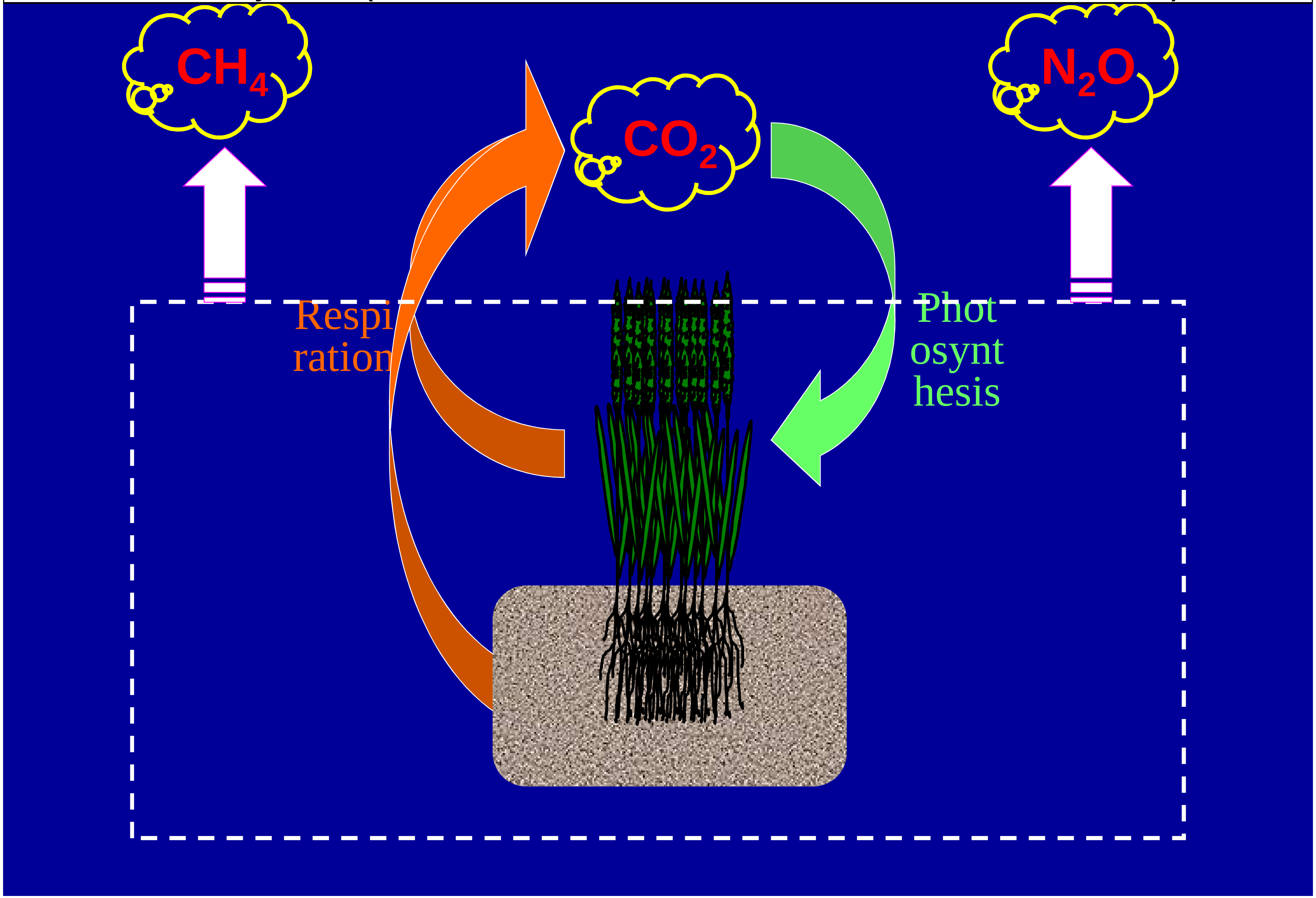
Outline

1 Background

- Nitrous oxide (N_2O) is an important greenhouse gas, its global warming potential in the 100-year window is 298 times greater than CO_2 (IPCC 2007).
- Furthermore, N_2O contributes to the depletion of the ozone layer in the stratosphere (Weatherhead et al. 2000).
- Soil respiration, including the autotrophic respiration of plant root and heterotrophic respiration of soil microbes, plays an important role in the global carbon cycle (Buchmann 2000; Schlesinger and Andrews 2000).

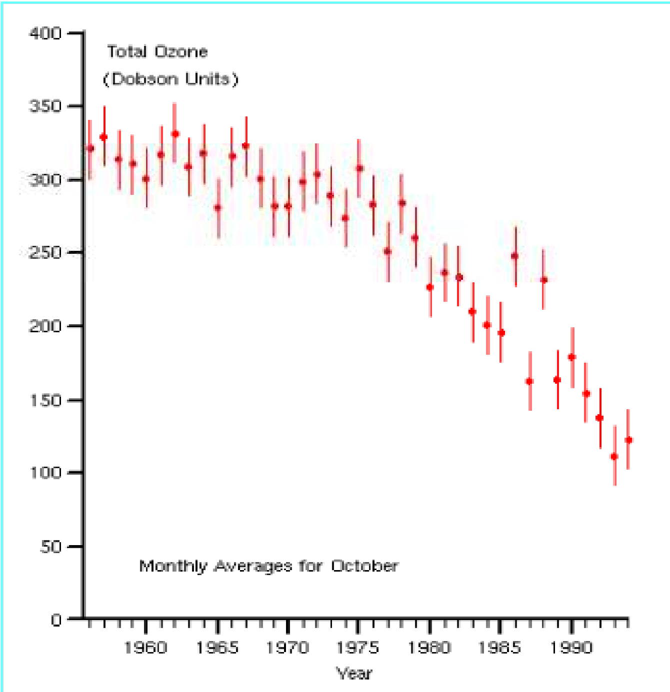
➢ Agroecosystem plays an important role in the carbon and nitrogen cycle of terrestrial ecosystem (IPCC, 2007; Rochette et al. 2004; Sun et al. 2007).

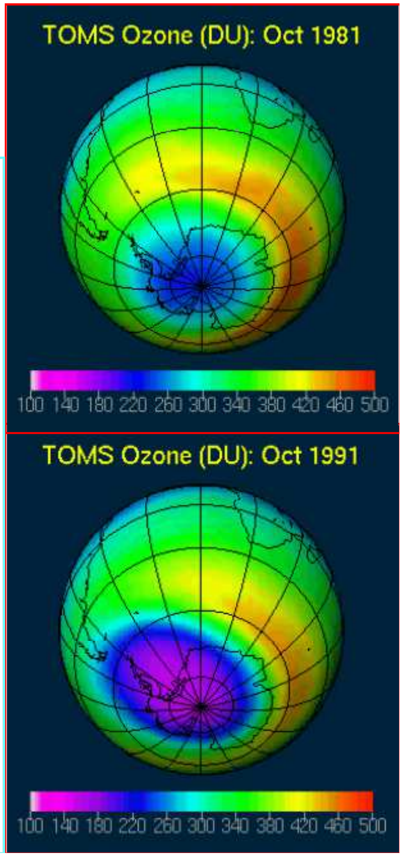


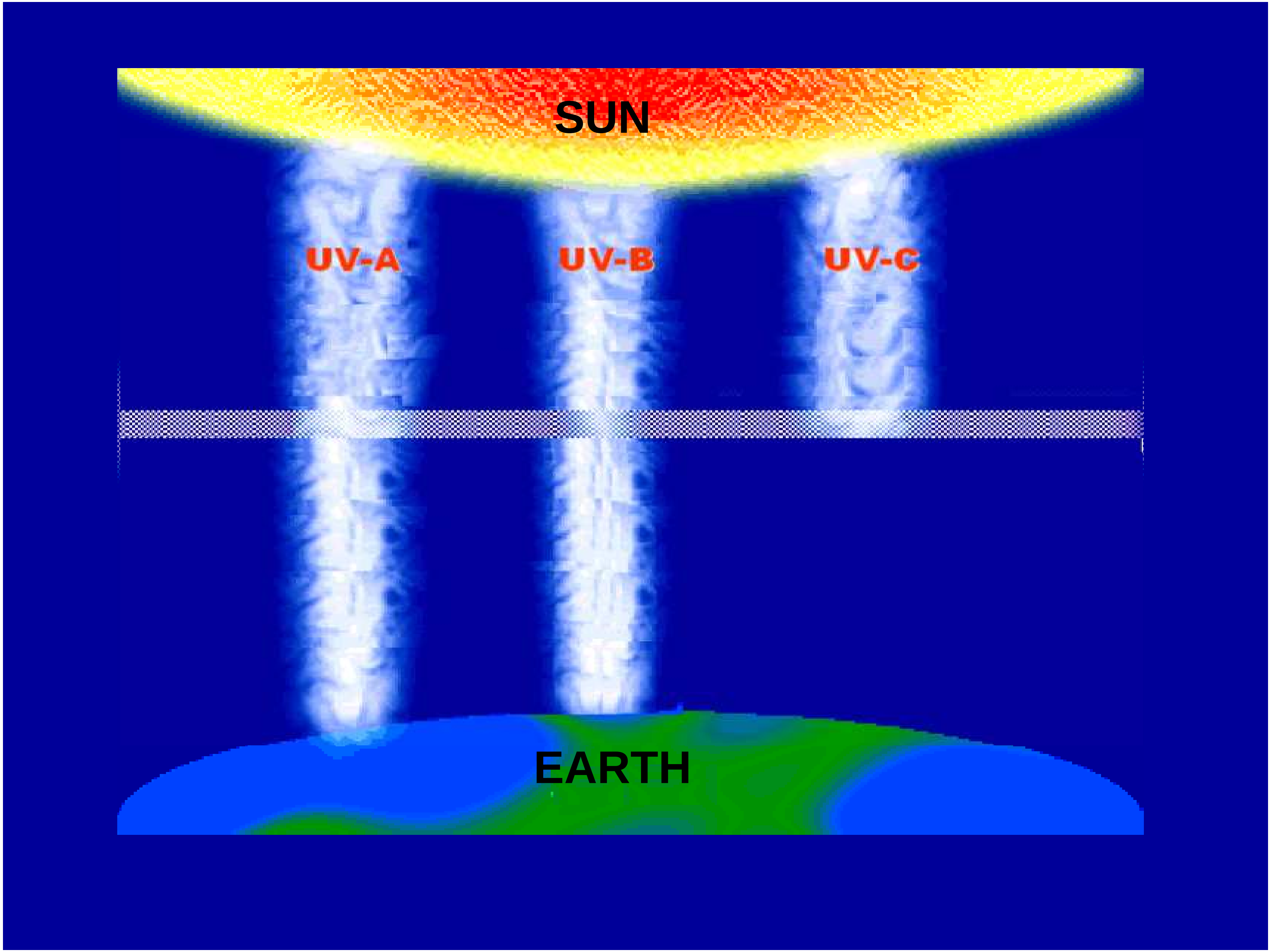
1 Background

- The significant increase in CFCs and N_2O contents lead to stratospheric ozone depletion, which has resulted in the enhancement of ultraviolet-B (UV-B) radiation reaching the earth’s surface (Rozema et al. 2005; Erickson et al. 2000).

- The stratospheric ozone recovery rate depends on many factors, including N_2O emissions (Weatherhead et al. 2000).






SUN
UV-A
UV-B
UV-C
EARTH

1 Background

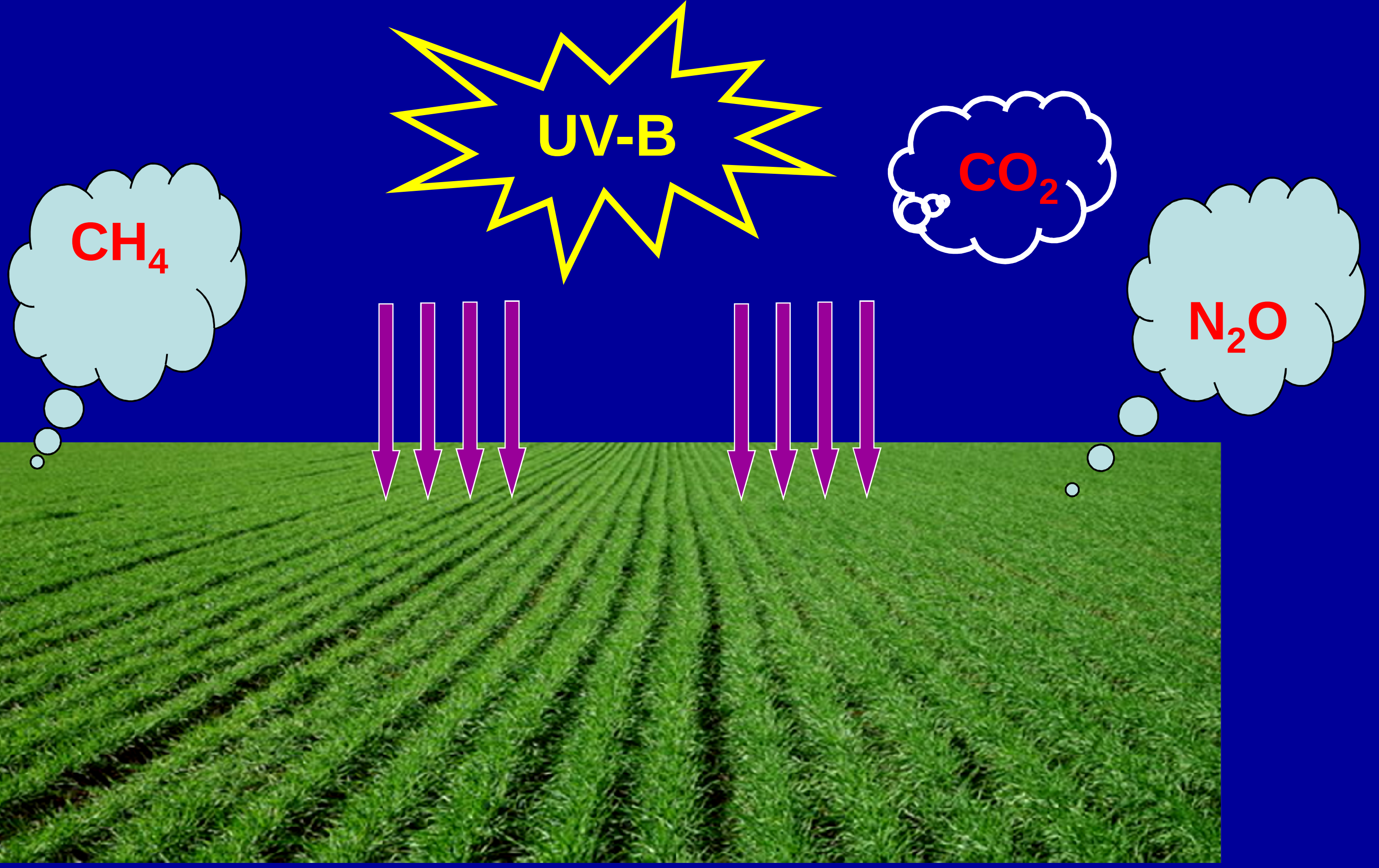
- Enhanced UV-B radiation decreases crop photosynthesis rates (e.g., Yang et al. 2007; Pandey and Chaplot 2007), inhibits crop growth (e.g., Kakani et al. 2003; Kadur et al. 2007), and reduces crop biomass (e.g., Yao et al. 2006; Agrawal et al. 2006).
- UV-B can influence indirectly the quantity and activity of soil microbial populations (Johnson et al. 2002, 2003; Robson et al. 2004).

Plant growth

Soil microorganisms

the main factors affecting SR and N_2O emissions in cropland

Hypothesis



2 Objectives

- to investigate the effects of enhanced UV-B radiation on soil respiration and N_2O emissions in the soybean- and winter wheat- growing seasons.
- to gain insight into the mechanism of enhanced UV-B radiation alter soil respiration and N_2O emissions in croplands.

3 Methods

3.1 Experimental site

- The experimental farm of Nanjing University of Information Science & Technology (32° 03′N, 118° 51′E), East China.
- The soil (0–20 cm) was classified as hydromorphic, 26.1% clay, pH(H_2O) 6.22, TOC 19.4 gkg^{-1}, and TN 1.45 gkg^{-1}.
- The field experiment was carried out during the soybean and winter wheat growing seasons.

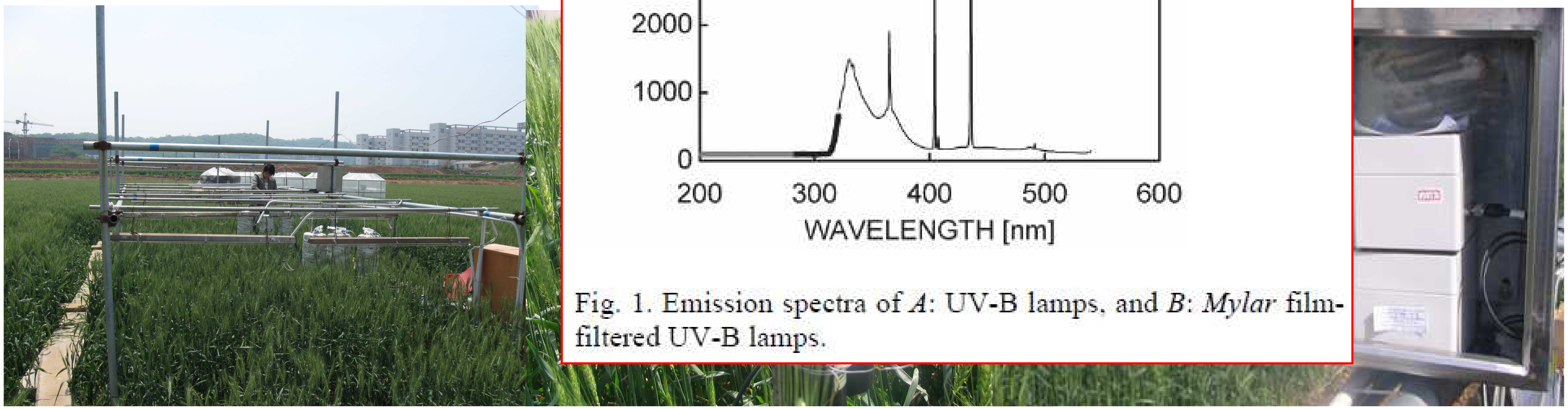
3.2 Experimental design

- The control (C, ambient UV-B radiation), UV-B treatment (U, with the 20 % enhancement of UV-B).
- Pot experiment: in each treatment, pots were arranged five rows, each row had six pots. In total, 60 pots were used.
- Field experiment: each treatment had three replicate plots (2×2m^2 area of each plot). Plots were randomly arranged in three blocks.



3.3 UV-B treatments

- Supplemental UV-B radiation was supplied with fluorescent UV lamps. Plants were ir
- C lamps were wrappe thickness; DuPont Co C.
- UV-B radiant intensit radiation sensors (28 data loggers (Skye-Datahc



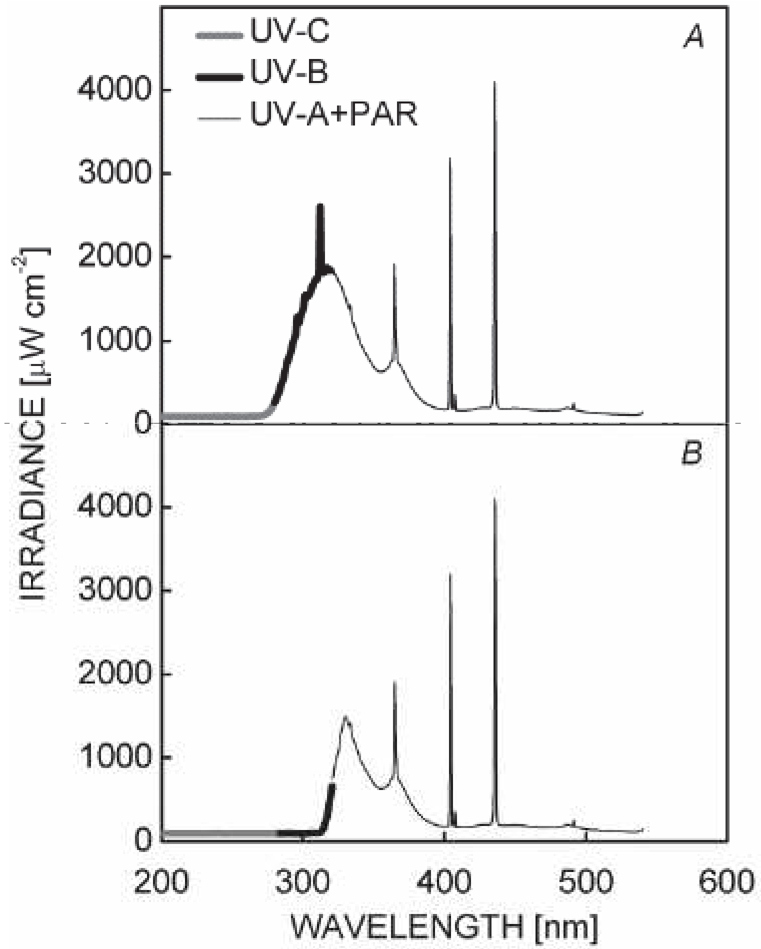


Fig. 1. Emission spectra of *A*: UV-B lamps, and *B*: *Mylar* film-filtered UV-B lamps.

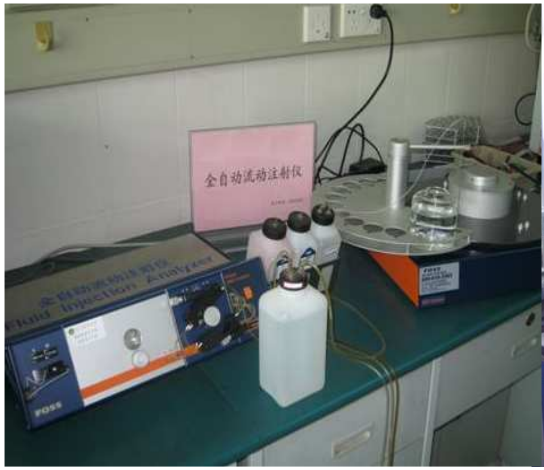
3.4 Soil respiration and N_2O Measurements

- Soil respiration: LI-8100.
- N_2O emission flux: a static chamber–gas chromatograph technique.
- The N_2O flux was determined from the slope of the changes in the mixing ratio with durations at 0, 10, and 20 min following chamber closure




3.5 Plant and Soil Samples Analysis

- Plant biomass.
- NO_3^--N, NH_4^+-N, and TN in soil and leaves.
- Microbial biomass C, N (Lu, 2000).
- Soluble protein content, and NR activity (Li, 2000).
- Soil temperature and moisture.





4 Results

4.1 Effects of enhanced UV-B on soil respiration

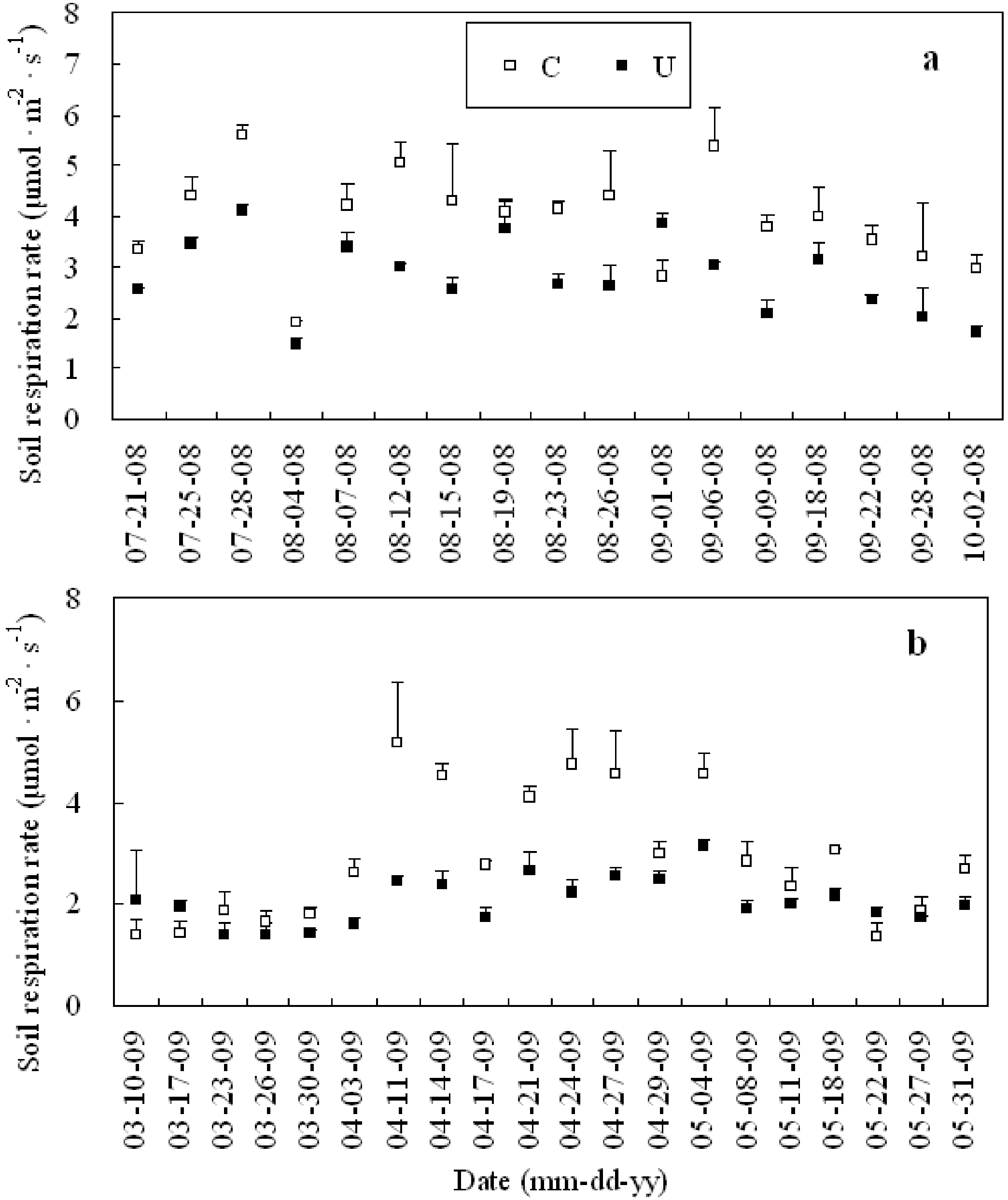


Fig. 2 Effects of enhanced UV-B on SR rates. a, b SR rates in the soybean- and winter wheat-growing seasons, respectively. Data are the mean values. Error bars are SEs

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4.1 Effects of enhanced UV-B on soil respiration

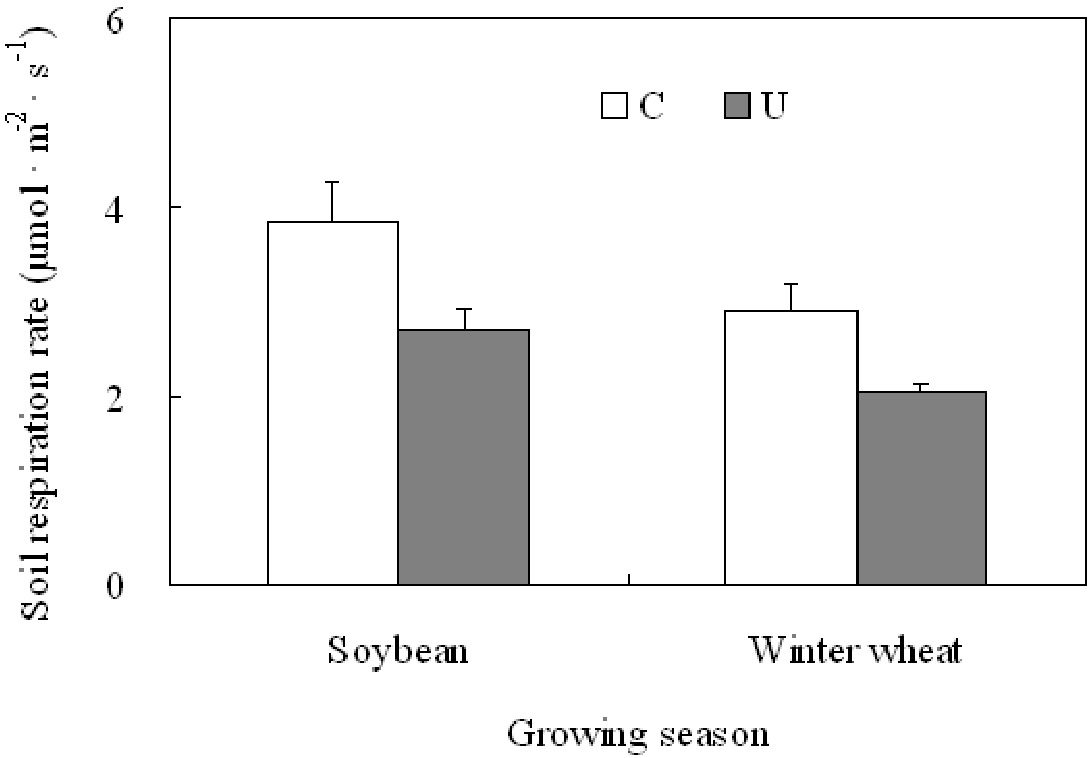

Fig. 3 Seasonal mean SR rates. Data are the mean values ± SE.

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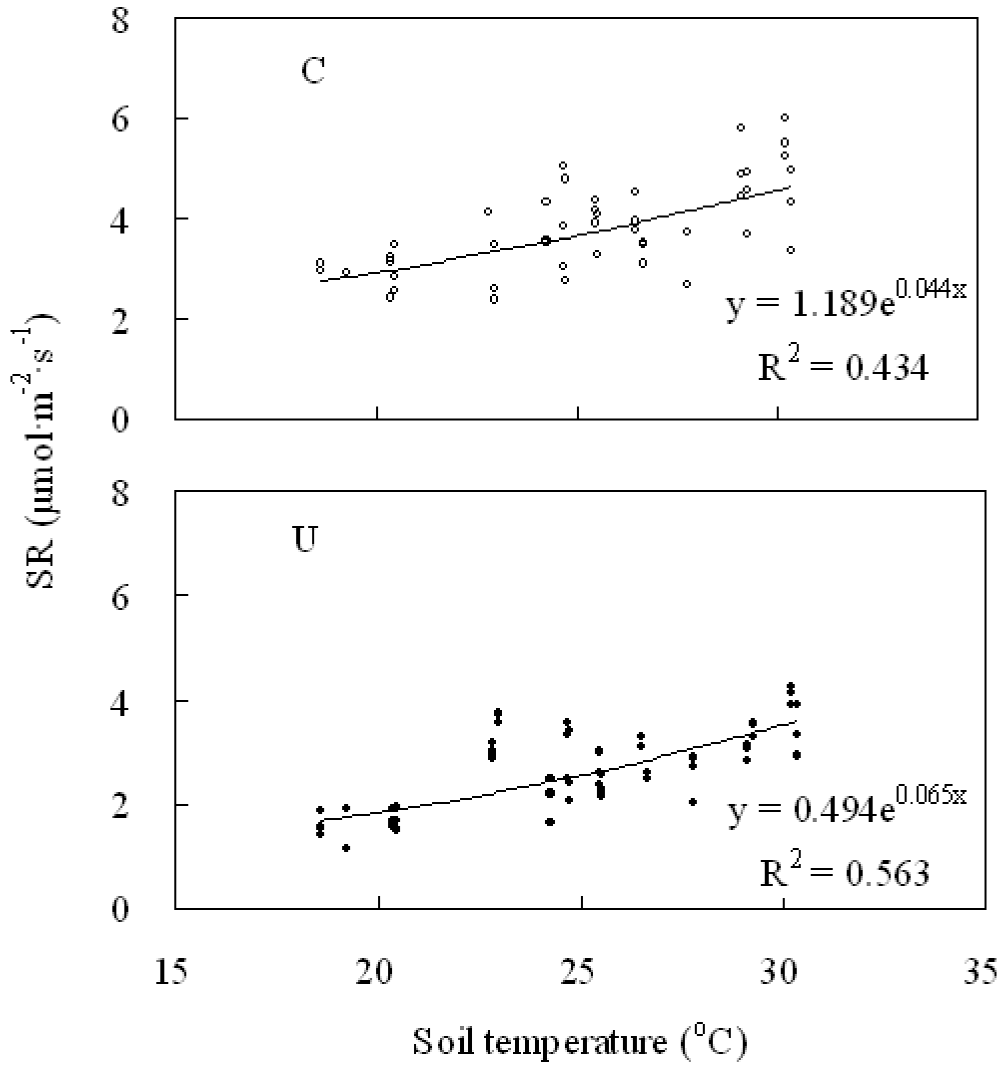
4.1 Effects of enhanced UV-B on soil respiration



Q_{10}

Fig. 4 Relationship between SR rates and soil temperature in the soybean-growing season.

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4.2 Effects of enhanced UV-B on **soil** N_2O emission

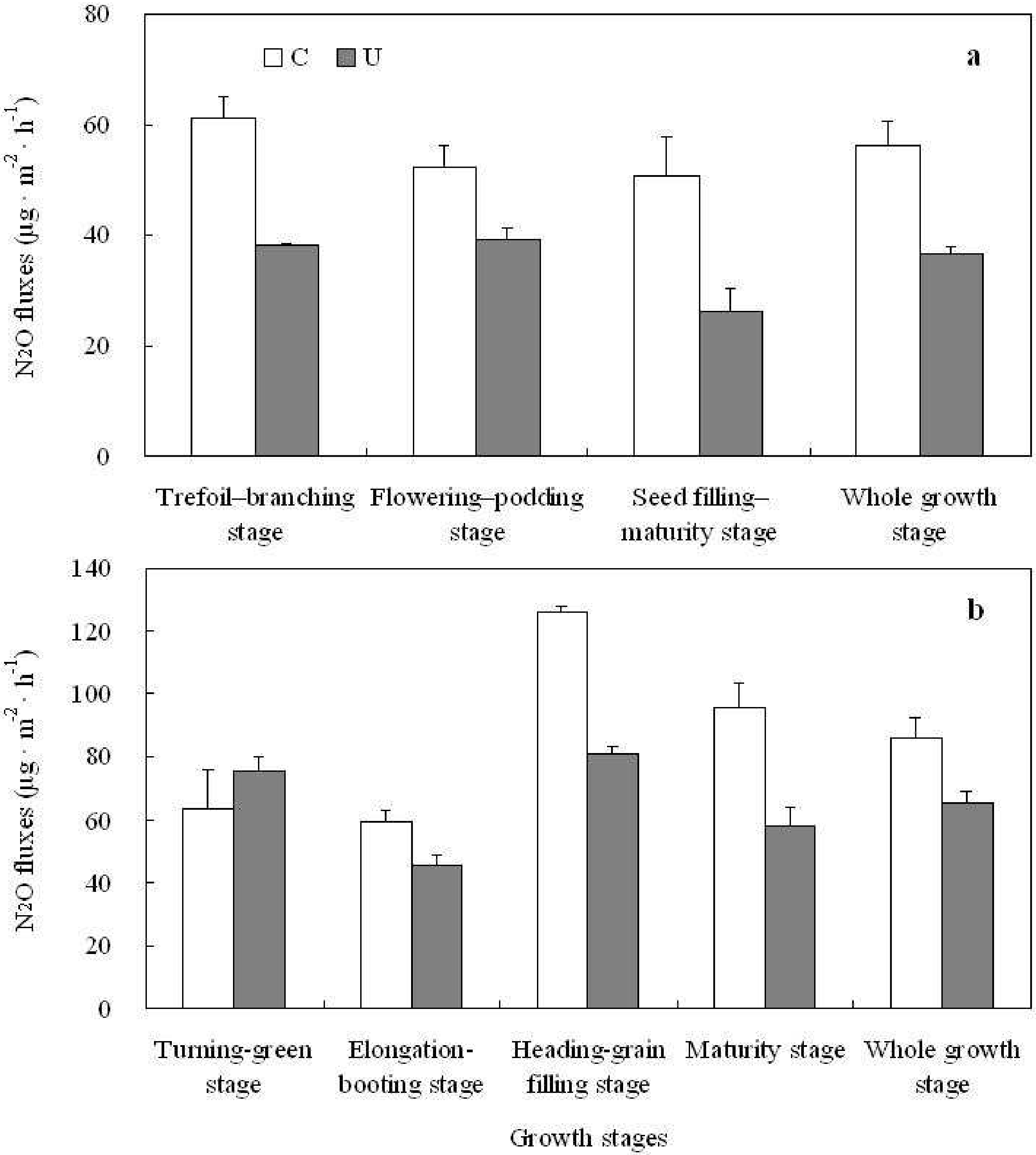

Fig. 5 Effect of enhanced UV-B radiation on the mean N_2O fluxes in different growth stages.
a, b in the soybean- and winter wheat-growing seasons, respectively.
Data are the mean values.
Error bars are SEs

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4.3 Effects of enhanced UV-B on N_2O emission from **soil-crop systems**

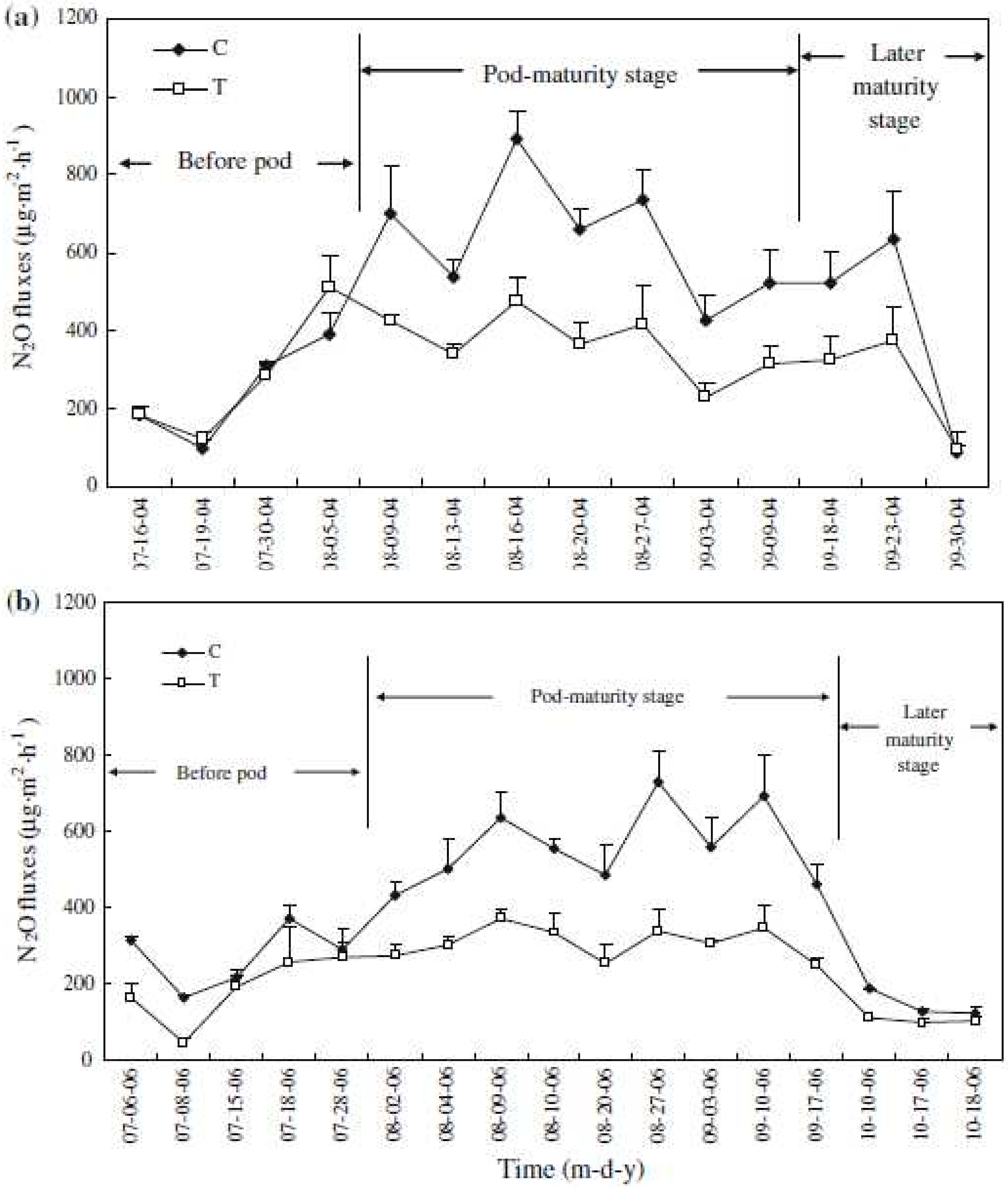

Fig. 6 Effects of enhanced UV-B radiation on N_2O fluxes (Mean + SD) from a **soil-soybean system** in the 2004 (a) and 2006 (b) seasons

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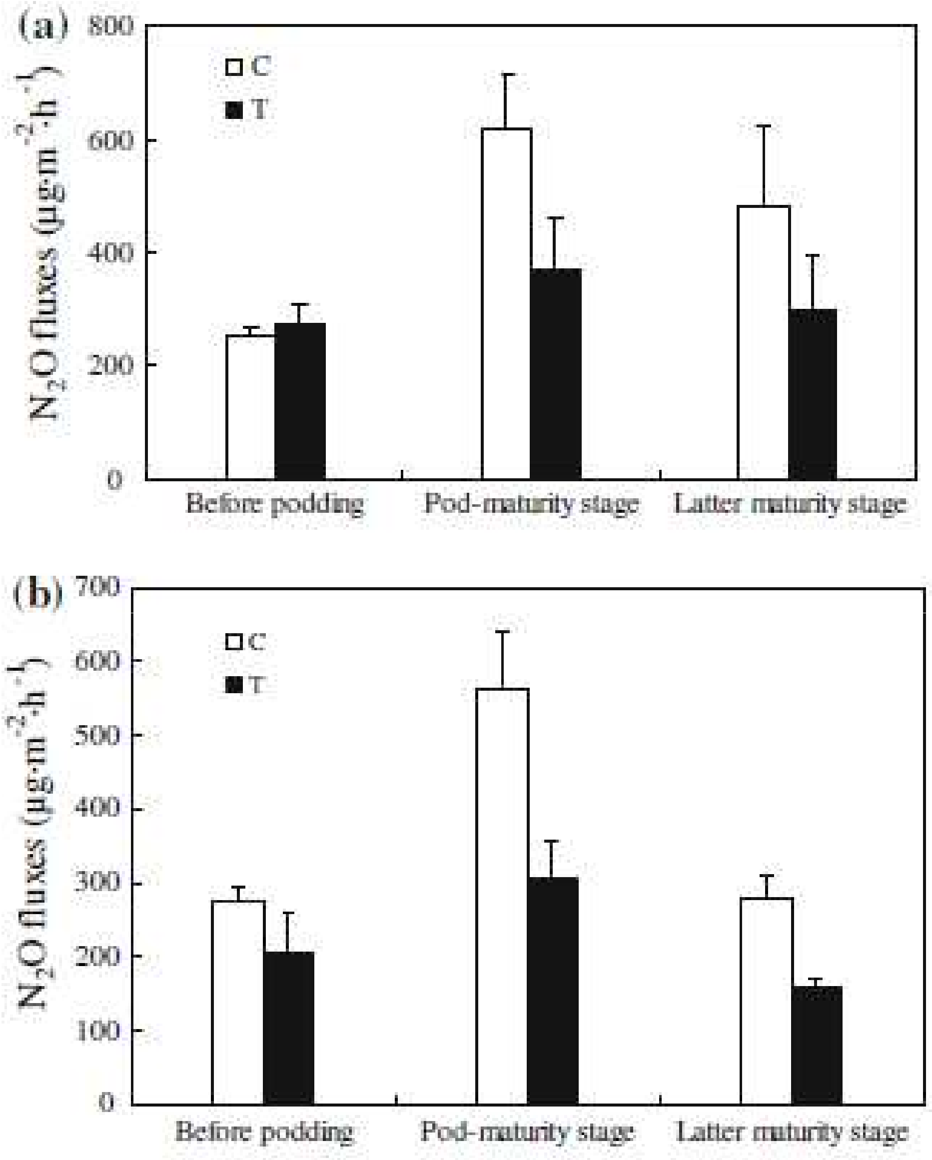

Fig. 7 Seasonal N_2O emissions (Mean + SD) from **soil-soybean system** during developmental stages in 2004 (a) and 2006 (b) seasons

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Table 1 Cumulative amount of N_2O from soil-soybean systems in 2004 and 2006 seasons

	2004 season		2006 season	
	C (mg m^{-2})	T (mg m^{-2})	C (mg m^{-2})	T (mg m^{-2})
Before podding	113.44 ± 6.17	121.79 ± 15.91	144.01 ± 8.78	104.50 ± 26.10*
Pod-maturity stage	519.54 ± 78.76	309.50 ± 78.88***	686.95 ± 97.61	375.01 ± 61.04***
Latter maturity stage	241.60 ± 71.45	150.59 ± 47.65*	208.89 ± 24.08	119.13 ± 8.62***
Whole growth stage	874.58 ± 146.60	581.88 ± 126.43**	1,039.86 ± 116.26	598.63 ± 89.52***

*, **, *** Designate the significant difference between control (C) and enhanced UV-B (T) treatments in ANOVA at $P = 0.10, 0.05$ and 0.01, respectively

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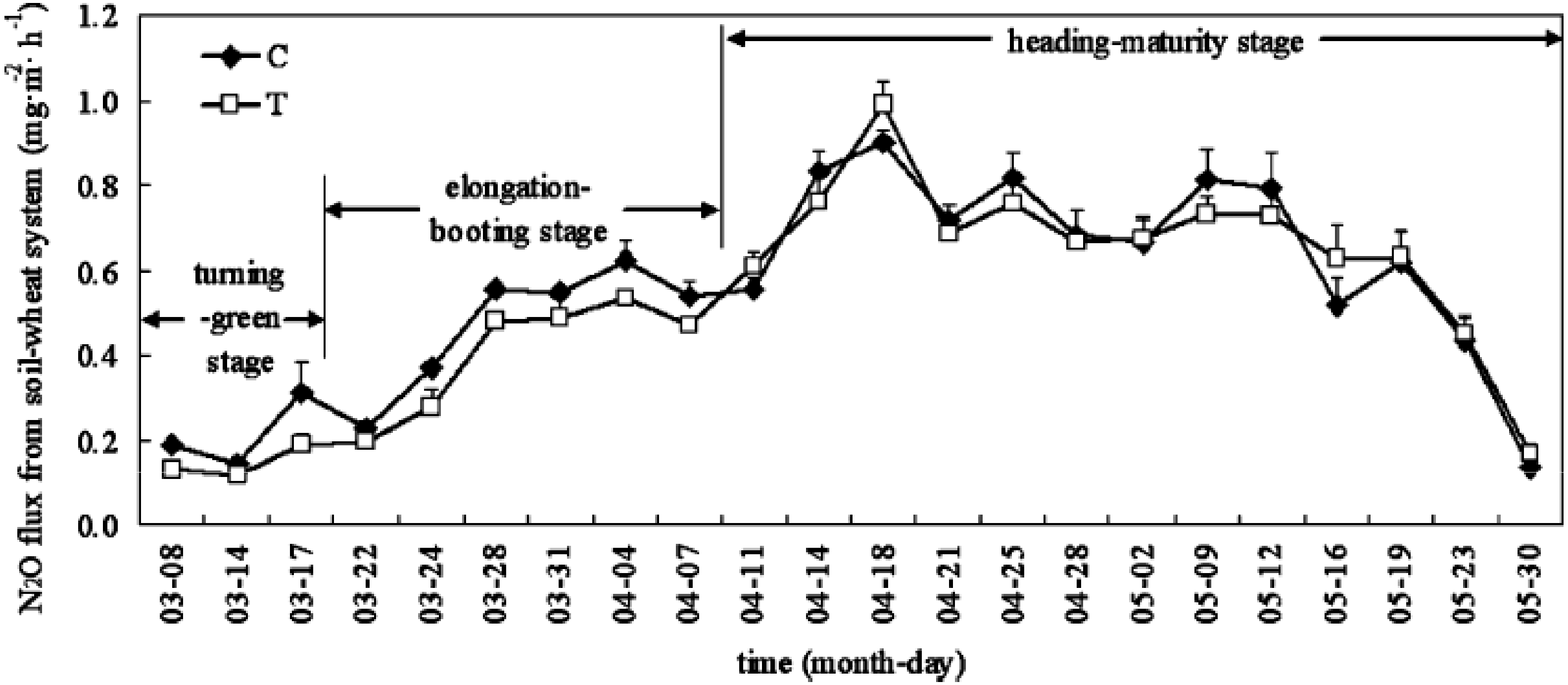

Fig. 8 Seasonal dynamics of N_2O flux from soil-winter wheat system. *C* and *T* represent the control and enhanced UV-B treatments, respectively

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4.4 Mechanism

➢ Biomass

Table 2 Effects of enhanced UV-B on the dry matter yield of winter-wheat in different stages (g·pot^{-1})

	Turning-green stage		Elongation-booting stage		Maturity stage	
	C	*T*	*C*	*T*	*C*	*T*
Root biomass	0.57±0.08	0.66±0.20	8.49±1.67	5.49±0.61	6.17±0.71	4.68±0.36
Shoot biomass	1.51±0.19	1.57±0.13	18.23±1.12	13.70±0.96[a]	50.71±4.39	42.54±4.09
Total biomass	2.08±0.21	2.22±0.32	26.71±2.53	19.18±1.56	56.88±5.05	47.22±3.99

The values are means ± standard errors, [a] designate the significant difference between C and T at p=0.05.

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➢ Biomass

Table 3 Effect of enhanced UV-B on soybean biomass (g/base frame). Data are the mean values ± SE. a, mean significant difference between C and U at *p*≤0.05

Treatments	Root biomass	Shoot biomass	Total biomass
C	2.87±0.16[a]	50.64± 2.46[a]	53.50±2.31[a]
U	0.91±0.10	13.21±1.17	14.12±1.26

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➢ Nitrogen metabolism in plant leaves

Table 4 Effects of enhanced UV-B on NO_3^--N content, nitrate reductase activities, and soluble proteins in wheat leaves

	Turning-green stage		Elongation stage	
	C	*T*	*C*	*T*
NO_3^--N/mg·kg^{-1}	348.56±20.21	361.4±46.7	161.31±8.76	190.40±14.08
NR activities/ U·(min mg)$^{-1}$	0.086±0.019	0.090±0.041	0.070±0.053	0.021±0.020
Soluble proteins/g kg^{-1}	29.28±2.71	24.61±0.52	33.63±1.47	44.02±3.23[a]

NR activities: nitrate reductase activities, [a] Significant difference between *C* and *T* at p=0.05.

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➢ Soil properties

Table 5 Effects of enhanced UV-B radiation on available N and microbial biomass in winter-wheat rhizosphere soil at elongation stage

	C	*T*
NO_3^--N/mg kg^{-1}	21.99±2.10	29.85±0.26[a]
NH_4^+-N/mg kg^{-1}	0.14±0.12	2.01±0.47[a]
microbial biomass C/μg g^{-1}	174.54±3.56	291.37±2.05[b]
microbial biomass N/μg g^{-1}	35.18±2.50	43.02±0.78[a]

[a] Difference between *C* and *T* at the significance level of $p<0.05$

[b] Difference between *C* and *T* at the significance level of $p<0.01$

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5 Conclusions

- Enhanced UV-B radiation lead to a decrease in soil respiration and in soil N_2O emissions.
- Enhanced UV-B radiation may lead to a decrease in N_2O emissions from soil-crop systems.
- Enhanced UV-B radiation increased soluble proteins content in leaves, NO_3^--N and NO_4^+-N content in rhizosphere soil, and soil microbial biomass C and N, as well as microbial biomass C:N ratio.

6 Shortage

- ➢ UV-B intensity control.
- ➢ Soil microbial populations.

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可调式 UVB 自动控制系统的研制

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摘要: 我们在中国科学院千烟洲生态网络实验站建立了国内一个可调式 UV-B 辐射自动控制系统, 用于模拟研究水稻对一定比例的地表 UVB 增强的反应。该系统能够根据阳光中 UVB 辐射强度的变化而自动增加和减少人工光源输出的 UV-B 辐射强度, 介绍了该系统的原理、结构及观测与控制效果。

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