Combined Effect of Diurnal Warming and Acid Rain on Soil Respiration and N_2O Emission in Farmland

Wu Yangzhou
yangzhou_wu@139.com

YNCenter Weekly Video Conference

2014.07.11

Outline

1 Background
2 Objectives
3 Methods
4 Results and Discussions
5 Conclusions
6 Next work

1 Background

Global warming and acid rain are very important atmospheric environmental issues today, which have been concerned by scholars at home and abroad, and farmland ecosystem plays an important role in the global greenhouse gases budget.

Table 1 Trends of global mean temperature change based on IPCC reports

IPCC reports	Rate(℃/100a)	Range(℃/100a)	Session
Ⅰ(1990)	0.45	0.3~0.6	1861~1989
Ⅱ(1996)	0.45	0.3~0.6	1861~1994
Ⅲ(2001)	0.60	0.4~0.8	1901~2000
Ⅳ(2007)	0.74	0.56~0.92	1906~2005
Ⅴ(2013)	0.85	-	1880~2012

1 Background

- The soil C pool in croplands is an important part of the overall terrestrial ecosystem C pool. Carbon sequestration from croplands plays an important role in global change (Smith 2004).

- **Soil respiration**, including the autotrophic respiration of plant roots and heterotrophic respiration of soil microorganisms, plays a key role in global C cycling (Buchmann 2000; Schlesinger and Andrews 2000).

- In addition, soil respiration and global warming closely influence each other (Sánchez et al. 2003; Schlesinger and Andrews 2000).

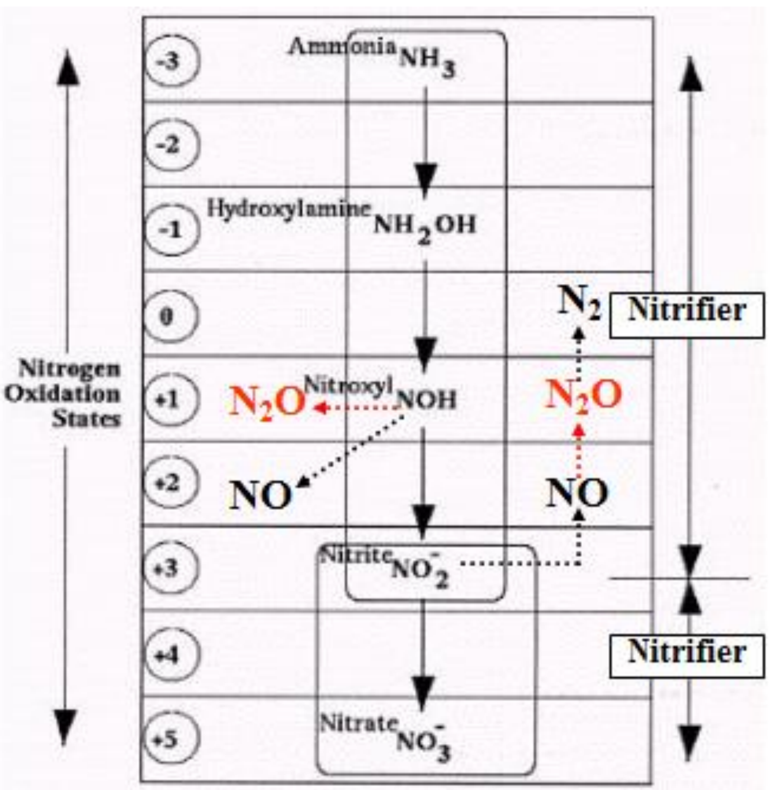
N_2O: a long-lived greenhouse gas in troposphere

	N_2O	CH_4	CO_2
Pre-industrial era con. (ppbv):	~ 275	~700	~280000
Present con. (ppbv):	319	1774	379000
Annual inrease (%/yr^{-1}):	0.25	0.6	0.4
Life time (yr):	114	12	50-200
Specific GWP (100 yr):	298	25	1

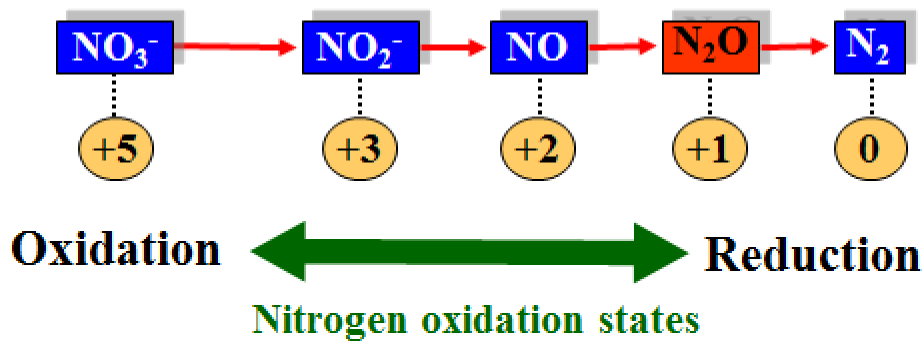
Source: IPCC, 2007

1 Background

- Nitrification and denitrification are important processes involving nitrogen (N) turnovers and removals from agricultural ecosystems (Müller, Stevens, and Laughlin 2004; Cookson et al. 2006). These processes are the main sources of nitrous oxide (N_2O) and nitric oxide (NO) from soils (Russow, Spott, and Stange 2008; Skiba, Smith, and Fowler 1993).



Microbial nitrification



Microbial denitrification

1 Background

- Diurnal warming is conducive to the growth and development of plants (Sandvik et al.,2004;Welker et al.,1997). Acid rain can inhibit the seed germination and seedling growth of plants (Fan et al.,2000).

- Diurnal warming can promote plant respiration, accelerate transformation of photosynthetic matter decomposition (Sheu et al.,1999). Acid rain could disrupt the normal metabolism of organs of nutrient elements (Wyrwicka et al.,2006).

1 Background

- Diurnal warming shows the indirect effects on soil properties, as it can decrease the soil organic C content (Konrad Martin,2011).Previous studies have suggested that acid rain could affect the soil N mineralization potential and N transformation (Suhayda et al,2004). These approaches could also alter the quantity and microbial activity of soil microorganisms, thereby affecting the soil N cycle (Johnston et al.,1986).

- Thus, the possible impacts of diurnal warming and acid rain on soil respiration, N_2O emission, and nitrification/denitrification in typical croplands need further investigation.

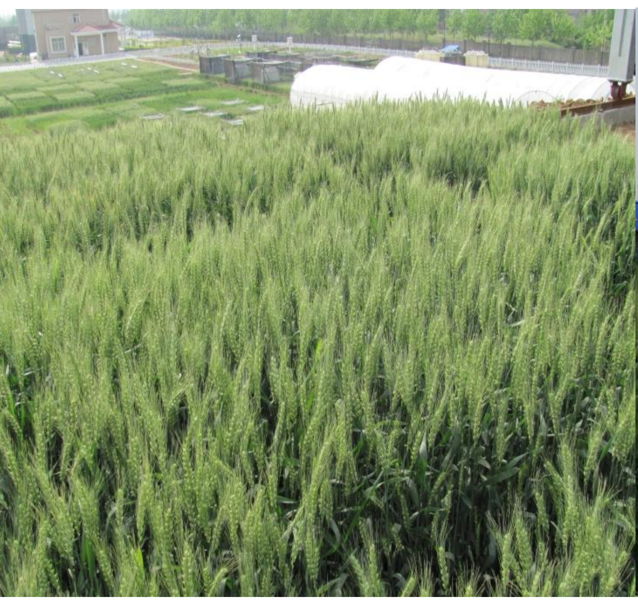
2 Objectives

- to investigate the effects of diurnal warming and acid rain on soil respiration rate, N_2O emission in cropland.
- to find out the mechanism.

3 Methods

3.1 Experimental site

A farmland at the Agricultural Meteorology and Ecological Experimental Station, NUIST, Nanjing.



3.2 Experimental design

Treatments:

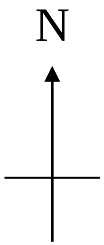
without warming or acid rain (CK),

diurnal warming (T),

acid rain(S)

diurnal warming with acid rain (ST).

CK	S	ST	CK	T	ST
T	ST	S	T	CK	S



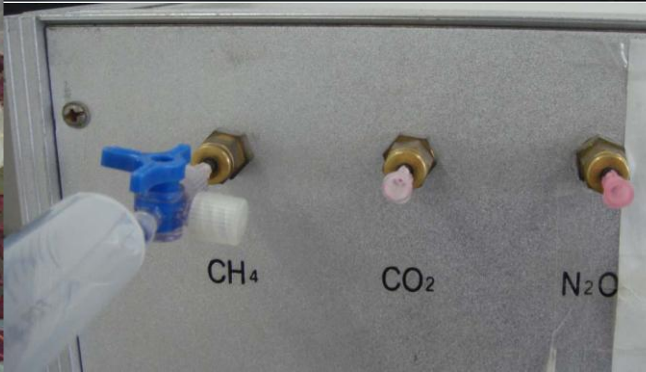
3.3 Soil respiration rate measurement

Li-8100 soil carbon fluxes system

3.4 N_2O fluxes measurement

Static chamber-gas chromatograph technique

$$F = \rho V \frac{dC}{dt}\frac{1}{A} = \frac{mP}{R(273+T)}\frac{V}{A}\frac{dC}{dt} = H\frac{mP}{R(273+T)}\frac{dC}{dt}$$



3.5 Nitrification rate measurement

BaPS technique:

the BaPS system was equipped with a container holding a maximum of seven soil cores. Circular stainless covers (7 cm in diameter) were used to collect soil samples.

3.6 Soil samples analysis

- Total nitrogen (TN)
- NO_3^--N
- TOC
- Soil enzymes (Invertase, Cellulose, Urease) activities

were determined by the protocols as described in *Methods for soil agrochemistry analysiss* (Lu 2000).

4 Results and Discussions

4.1 Soil temperature and moisture

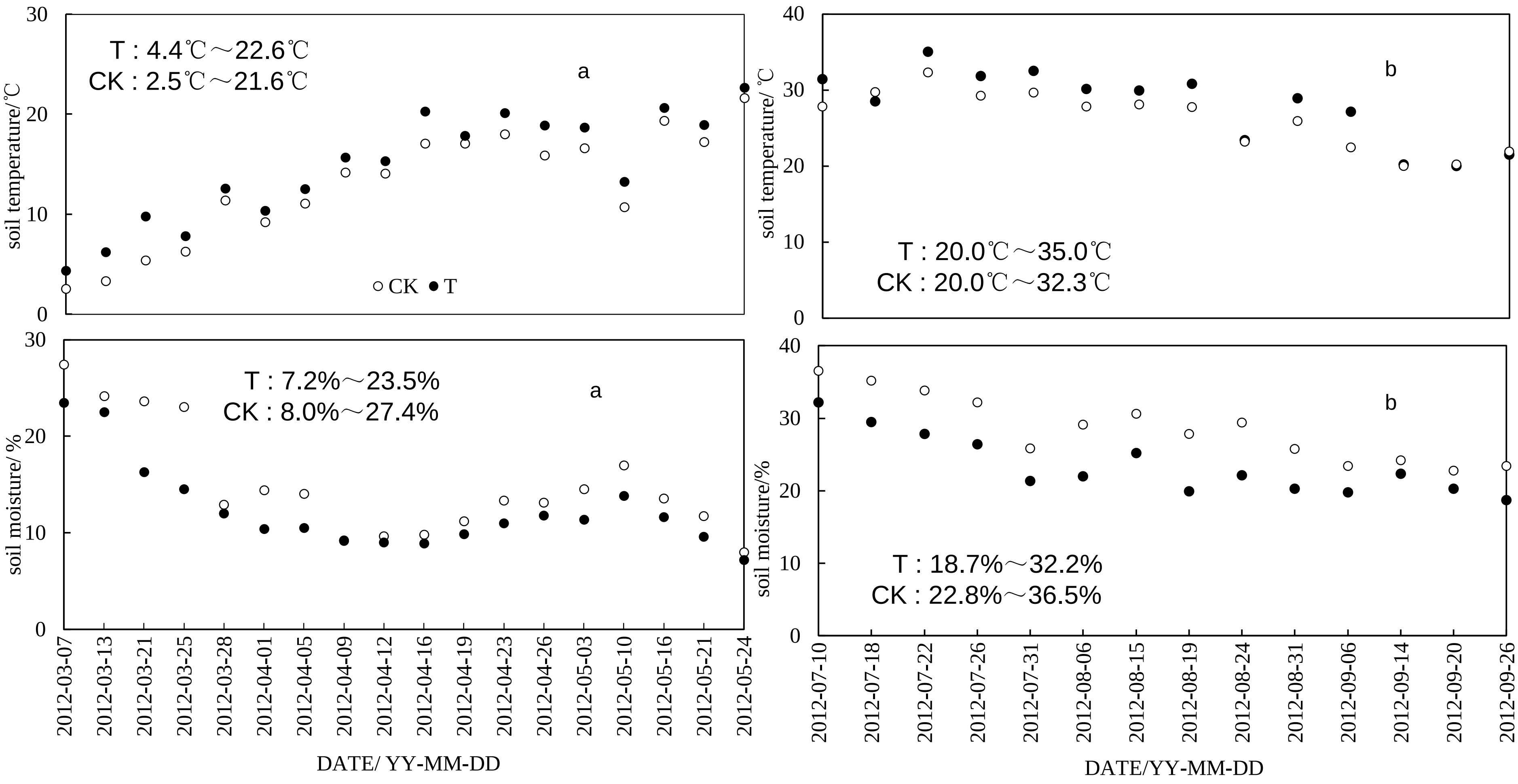


Fig. 1 Seasonal variation in soil temperature and soil moisture
a(winter wheat),b(soybean)

4.2 Soil Respiration

4.2.1 soil respiration from winter wheat

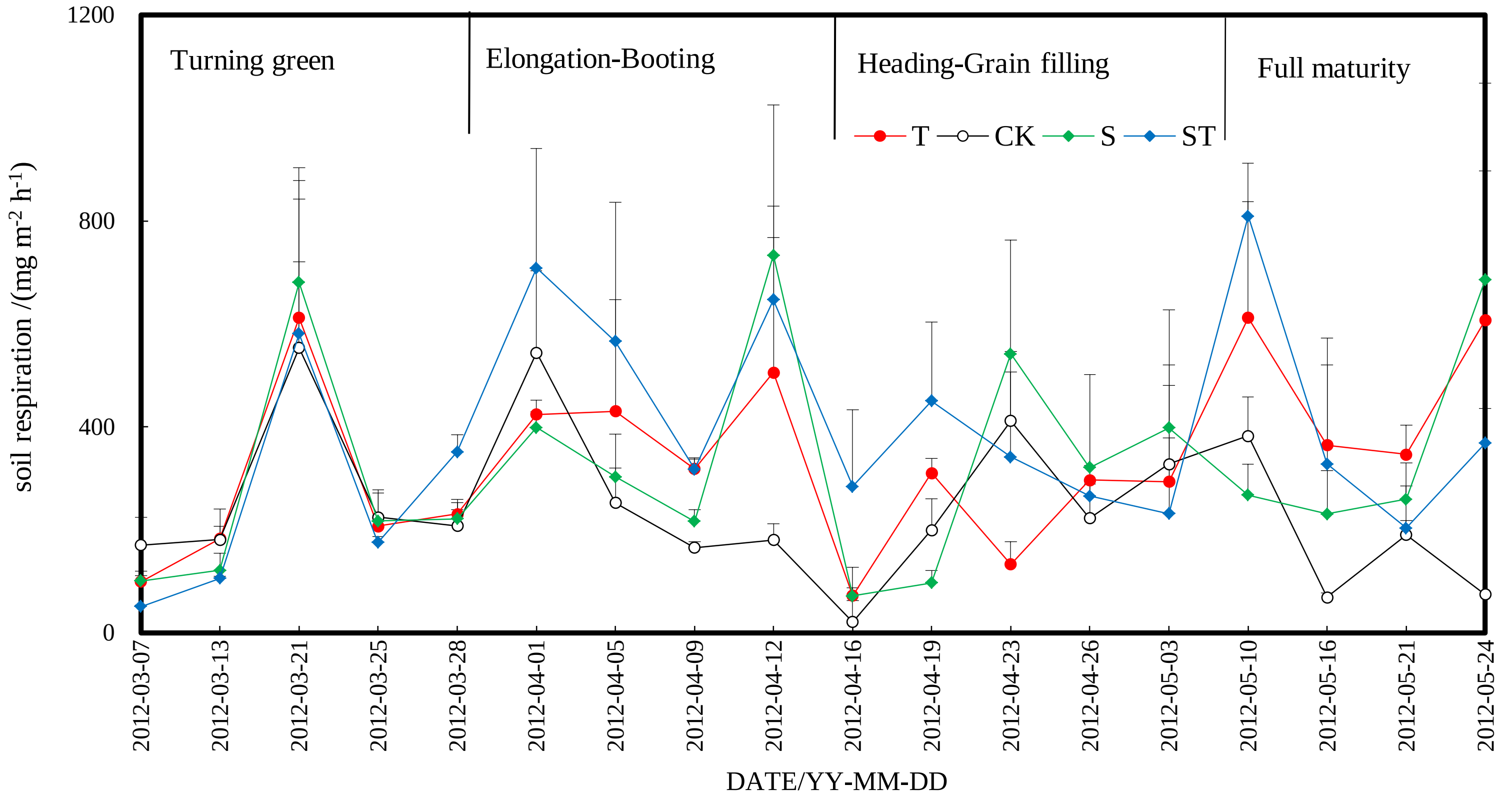


Fig. 2 Seasonal variation in soil respiration rates. Data are the mean values. Error bars are SEs

Table 1 Effect of diurnal warming and acid rain on average CO_2 fluxes from soil/($mg\cdot m^{-2}\cdot h^{-1}$)

	Turning green	Elongation-Booting	Heading-Grain filling	Full maturity	whole growth period
CK	267.6±82.7	285.0±23.3	261.2±56.2	111.5±15.3	243.5±32.9
T	266.5±69.9	419.9±115.1	286.5±27.0	439.5±88.5*	336.1±31.4
S	268.3±15.9	413.0±104.6	284.7±93.4	392.1±198.3	326.5±76.5
ST	253.0±65.6	560.1±119.2*	397.2±96.3	300.0±128.5	377.1±94.7

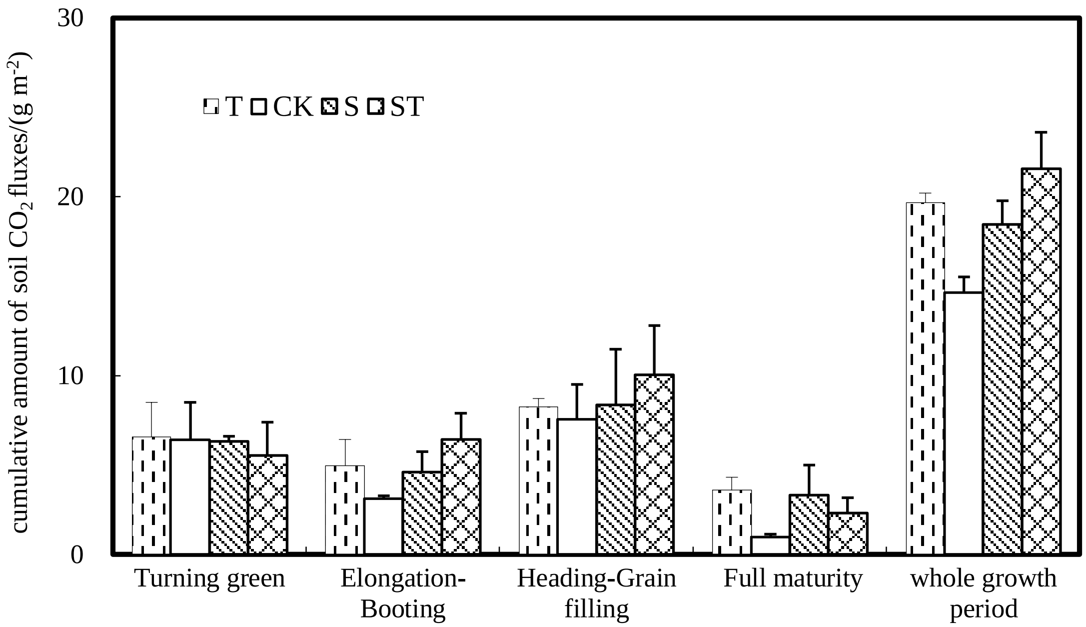


Fig. 3 Effect of diurnal warming and acid rain on cumulative amount of CO_2 fluxes from soil of winter wheat

4.2.2 soil respiration from soybean

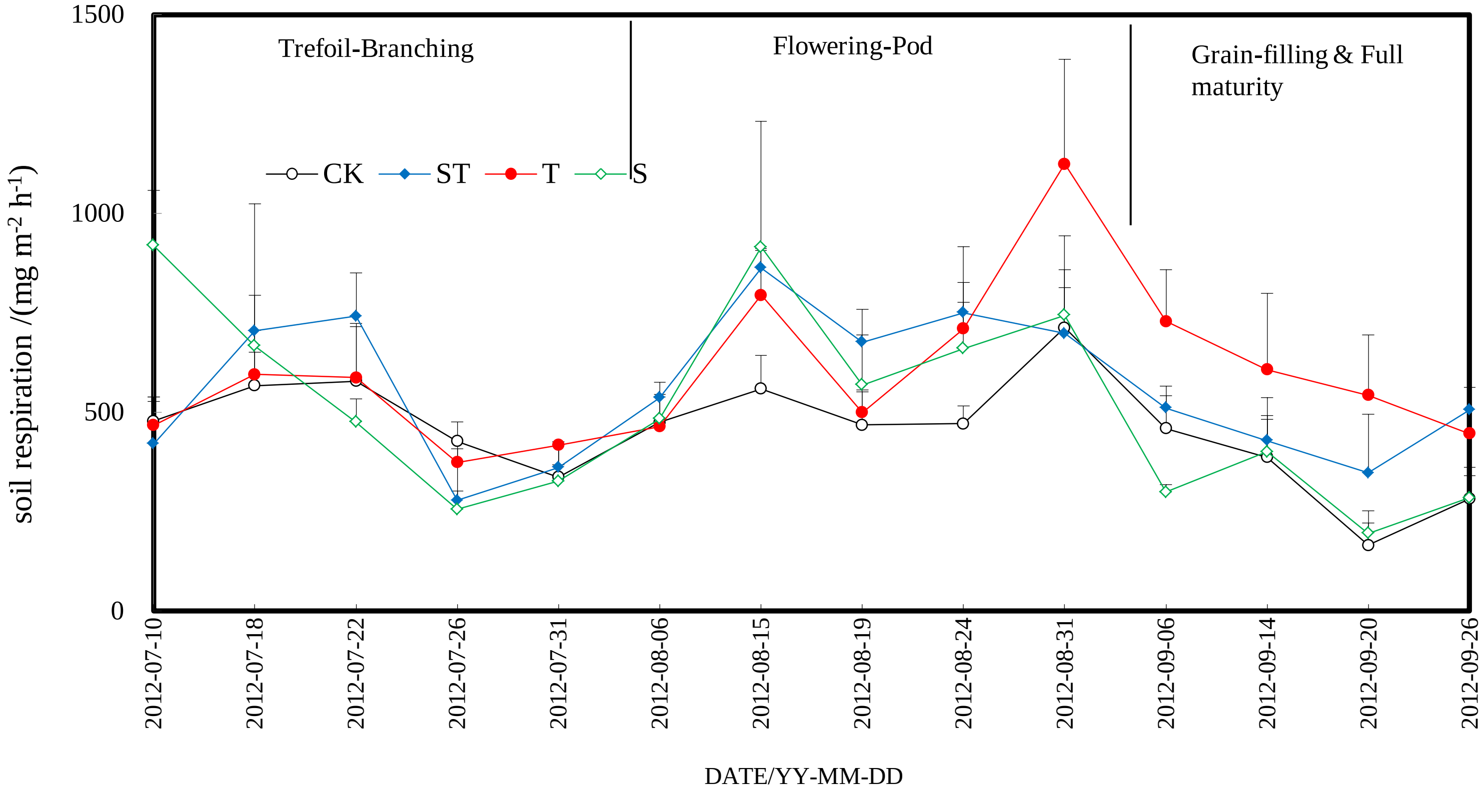


Fig. 4 Changes of soil respiration from soybean soil in growing season

Table 2 Effect of diurnal warming and acid rain on average CO_2 fluxes from soil/($mg \cdot m^{-2} \cdot h^{-1}$)

	Trefoil-Branching	Flowering-Pod	Grain-filling & Full maturity	whole growth period
CK	477.1±74.89	493.1±102.06	401.5±128.41	454.7± 42.88
T	487.7±52.25	617.1±160.99	690.0 ±235.69	596.9±120.29
S	528.3±134.77	656.9±262.64	384.8 ±99.71	513.8±152.73
ST	500.7±118.01	706.5±74.62*	498.1±147.91	558.6±98.53

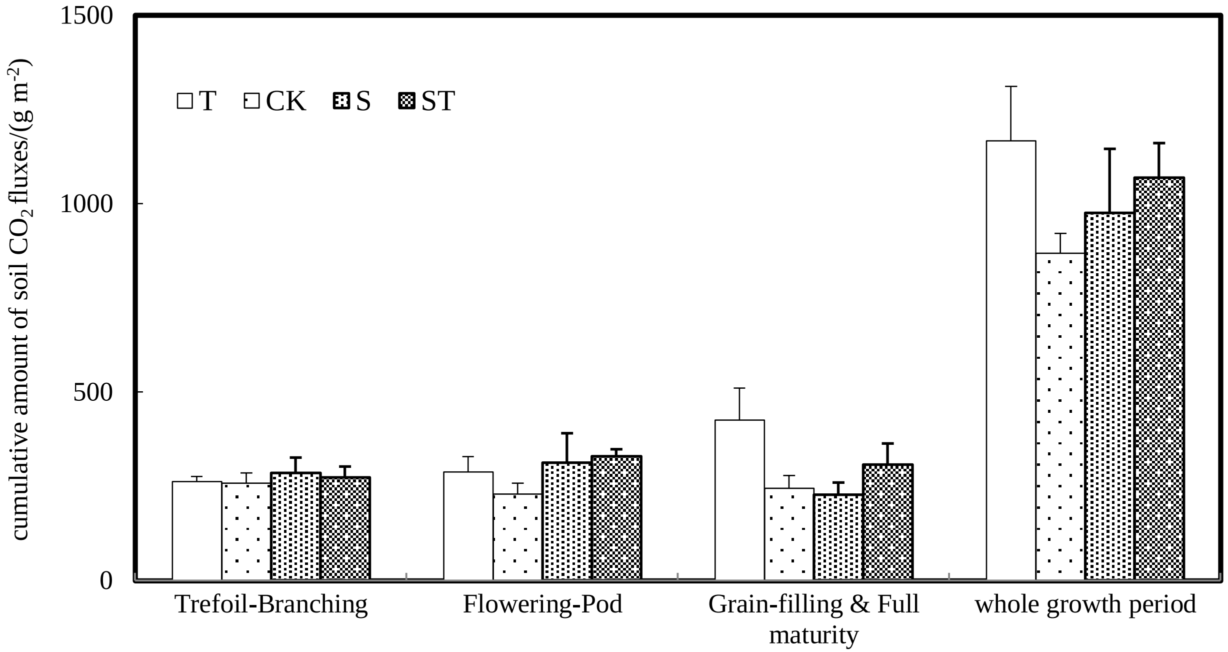


Fig. 5 Effect of diurnal warming and acid rain on cumulative amount of CO_2 fluxes from soil of soybean

4.3 N_2O emission

4.3.1 N_2O emission fluxes from winter wheat soil

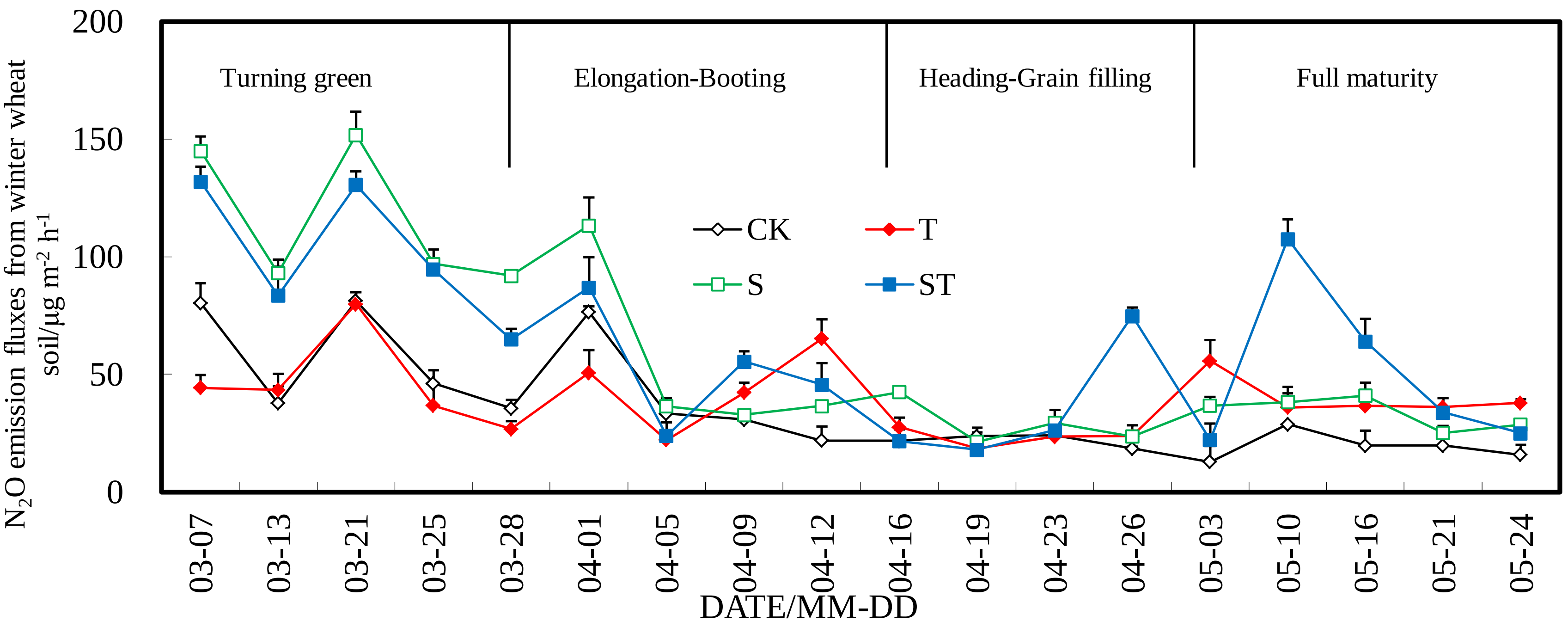


Fig. 6 Effect of experimental warming and acid rain on N_2O emission fluxes from winter wheat soil

Table 3 Effect of experimental warming and acid rain on average N_2O emission fluxes from winter wheat soil

	Turning green	Elongation-Booting	Heading-Grain filling	Full maturity	whole growth period
CK	56.2±1.51	40.6±2.80	22.0±1.54	21.0±0.25	34.9±0.30
T	46.2±1.71**	45.0±2.19	23.3±1.68	36.6±5.07**	39.2±1.20**
S	115.8±3.73**	54.8±2.59**	29.2±0.40**	33.3±1.72**	60.3±1.17**
ST	101.1±0.78**	53.0±5.90**	35.1±2.20**	57.6±4.33**	61.7±1.37**

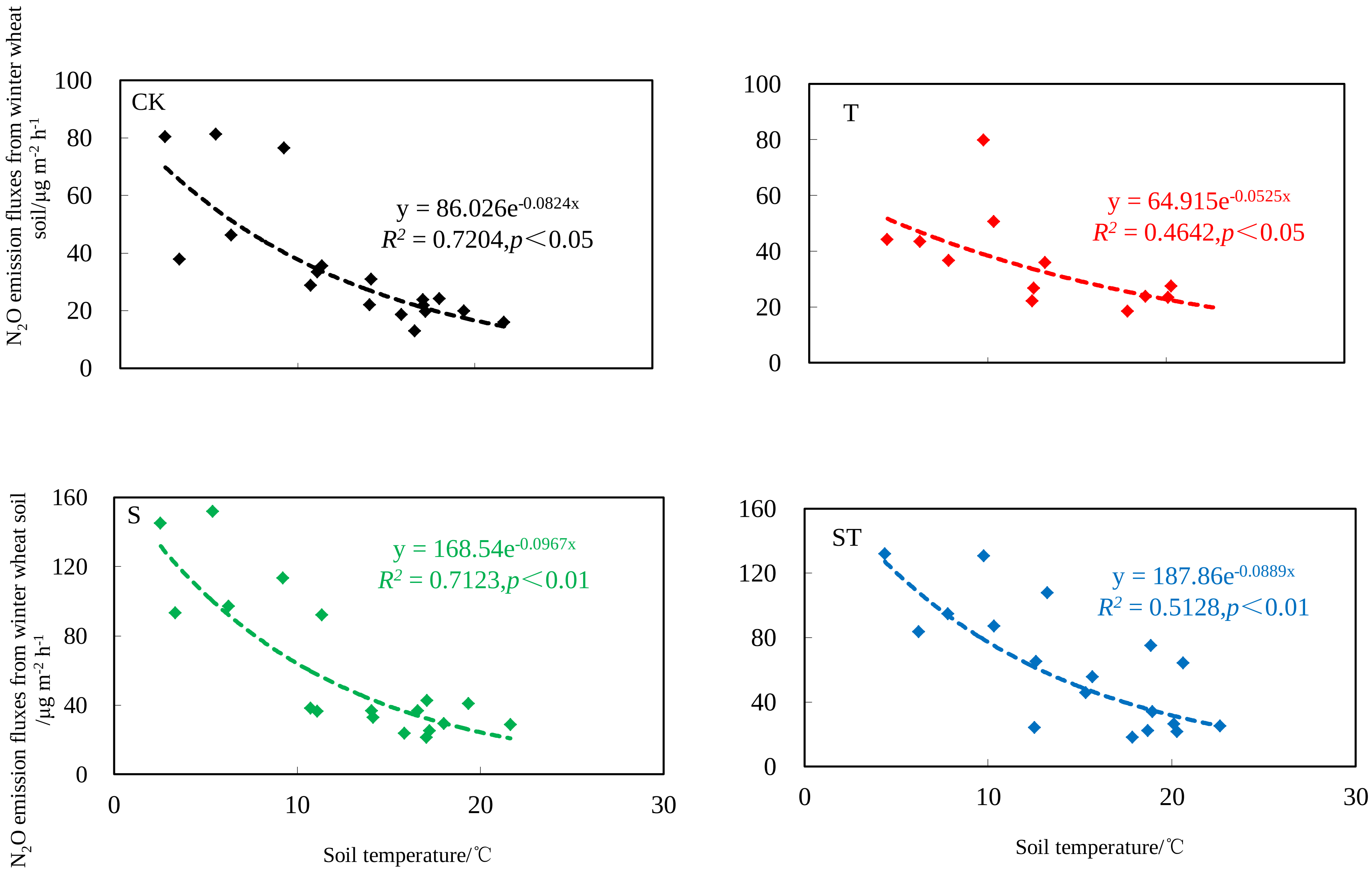


Fig. 7-1 Relationship between soil N_2O emissions fluxes and temperature

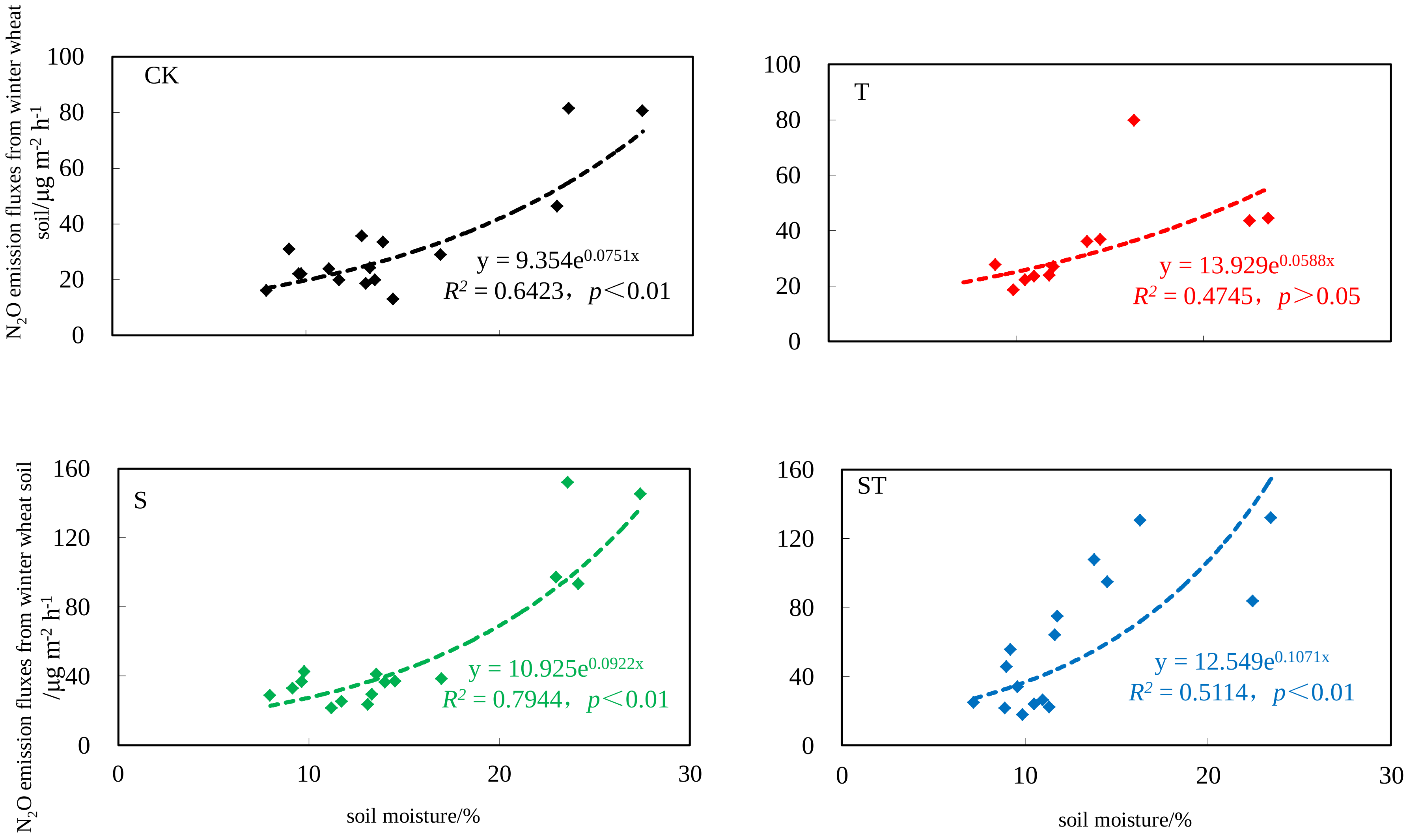


Fig. 7-2 Relationship between soil N_2O emissions fluxes and moisture

4.3.2 N_2O emission fluxes from soybean soil

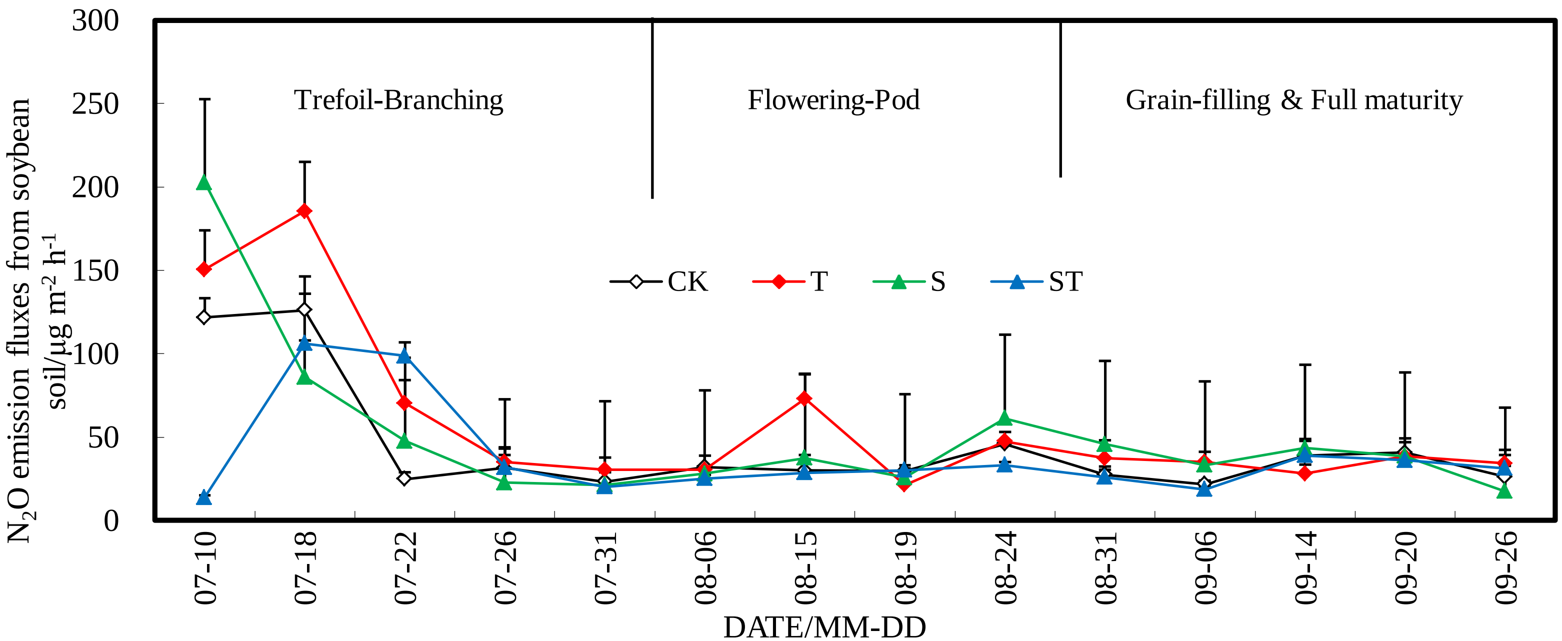


Fig. 8 Effect of experimental warming and acid rain on N_2O emission fluxes from soybean soil

Table 4 Effect of experimental warming and acid rain on average N_2O emission fluxes from soybean soil

	Trefoil-Branching	Flowering-Pod	Grain-filling & Full maturity	whole growth period
CK	65.6±3.93	34.4±2.69	31.0±3.25	44.3±1.69
T	79.3±10.04*	43.0±2.62**	34.6±6.12	53.0±4.26**
S	76.1±4.85	38.2±1.40	35.7±1.40*	50.9±2.81*
ST	54.2±2.93	29.3±2.02*	30.2±2.02	38.5±2.25*

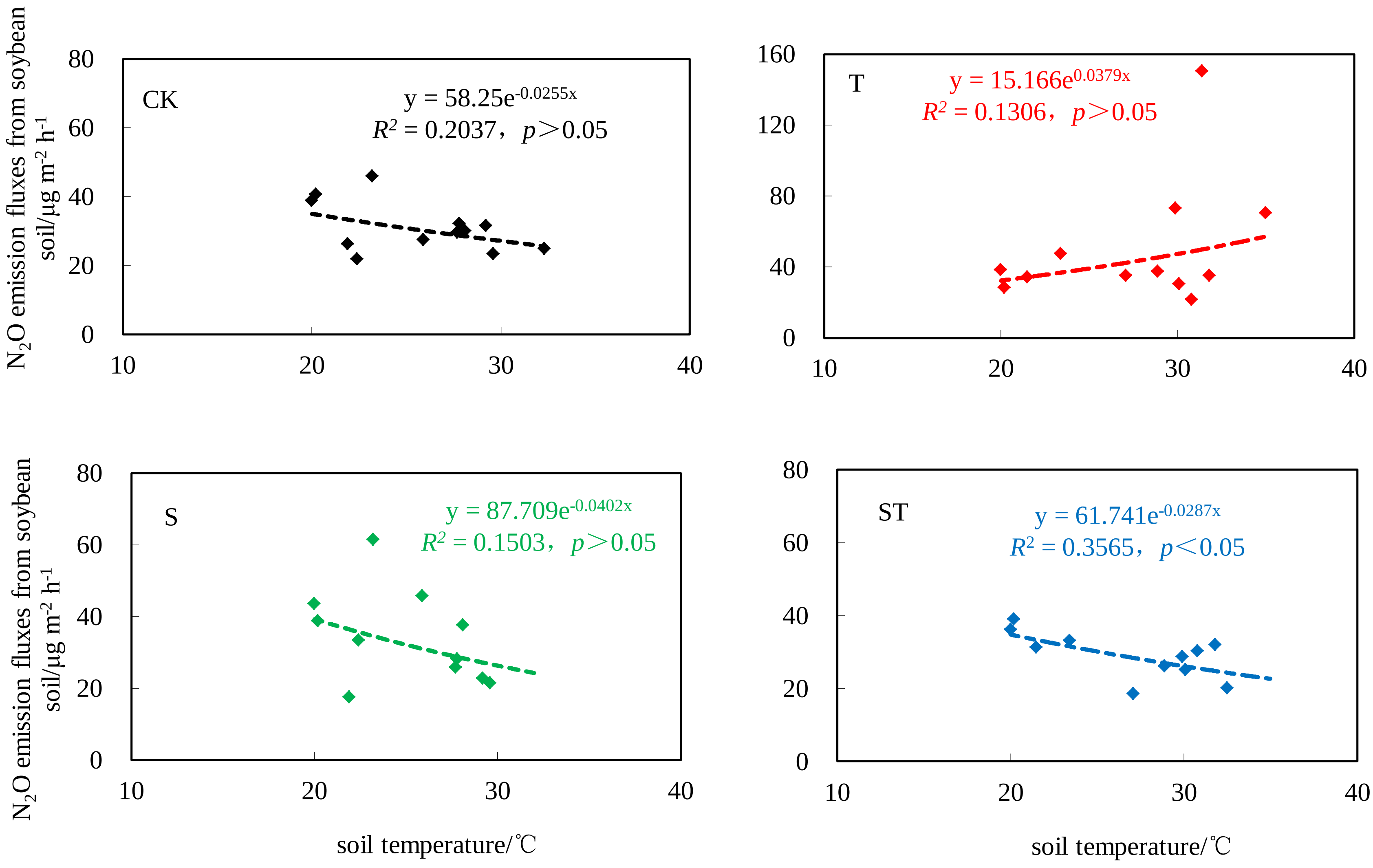


Fig. 9-1 Relationship between soybean soil N_2O emissions fluxes and temperature

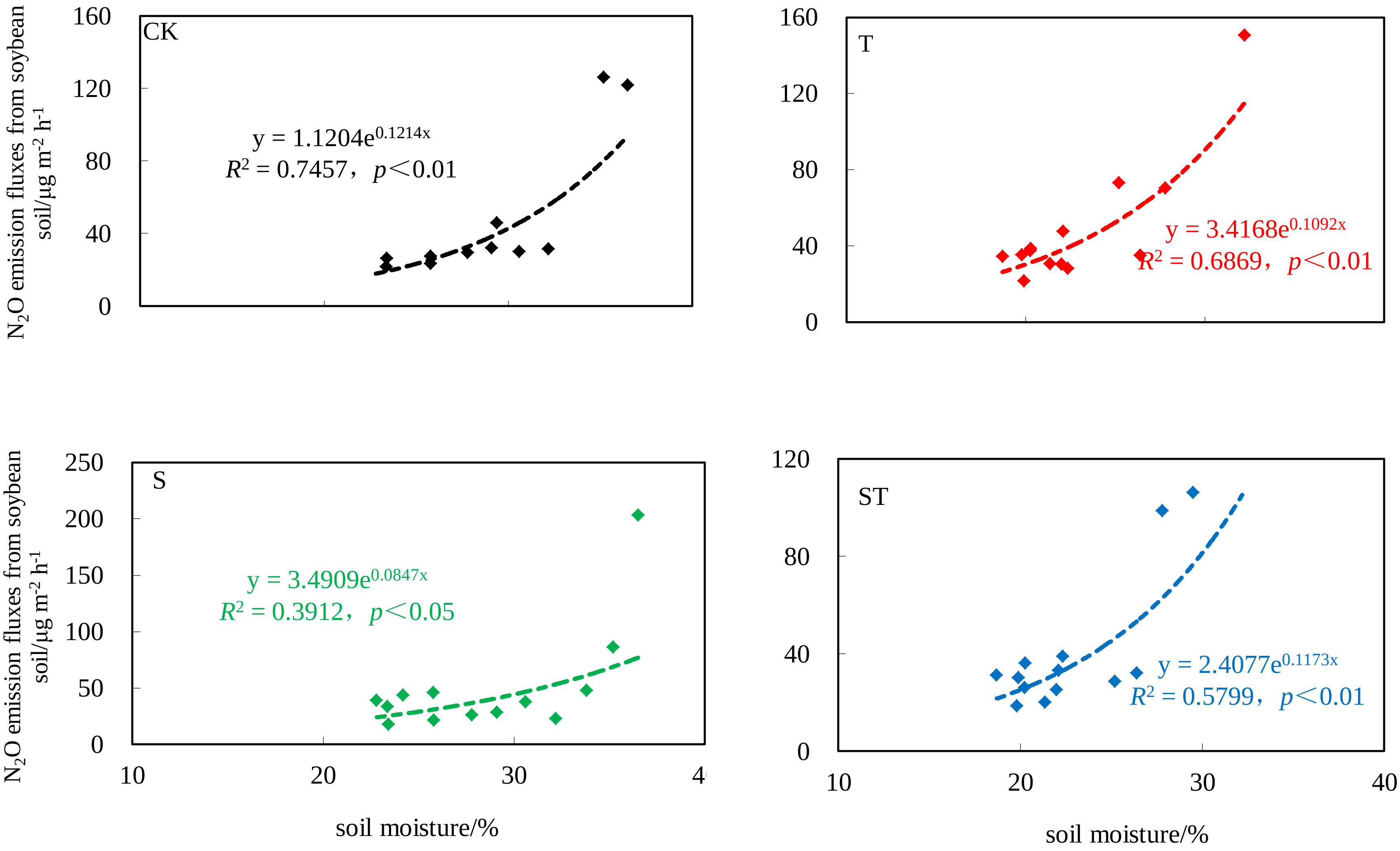


Fig. 9-2 Relationship between soybean soil N_2O emissions fluxes and temperature

4.4 Soil properties under different treatments

Table 5 Effect of experimental warming and acid rain on the whole growing stage biomass of winter wheat (g/pot)

	plants	root	total
CK	46.99±0.99	5.91±0.12	52.91±1.05
T	37.82±1.65**	4.46±0.32**	42.28±1.66**
S	38.44±0.96**	4.14±0.58**	42.58±0.51**
ST	37.13±0.88**	3.62±0.33**	40.75±1.05**

Table 6 Effect of experimental warming and acid rain on the whole growing stage biomass of soybean (g/pot)

	plants	root	total
CK	16.71±0.42	1.56±0.35	18.27±0.61
T	24.64±0.89**	1.64±0.28	26.27±0.99**
S	16.78±1.00	1.30±0.07	18.08±1.01
ST	20.28±0.23**	1.46±0.39	21.73±0.27**

Table 7 Organic carbon content (TOC) in soil of winter wheat in different developmental stages / $g \cdot kg^{-1}$

	CK	T	S	ST
Turning green	30.87±2.18	27.68±2.06	26.54±3.08	27.34±3.30
Elongation-Booting	31.21±1.78	31.66±1.65	31.89±4.64	34.17±0.71
Heading	29.61±5.03	31.55±0.41	31.78±1.88	33.26±2.97
Grain filling	35.65±2.57	35.88±3.10	28.59±0.75*	25.85±0.60*
Full maturity	24.49±3.31	21.98±1.39	19.48±1.97	21.19±0.71

Data are the mean values±SE. Different lowercase letters denote significant difference among different treatments at $p \leq 0.05$. The same below.

Table 8 Organic carbon content (TOC) in soil of soybean in different developmental stages / $g \cdot kg^{-1}$

	CK	T	S	ST
Trefoil-Branching	26.94±1.64	31.29±4.25	29.71±2.43	24. 72±3.30
Flowering-Pod	25.64±0.64	23.07±0.90	25.09±2.71	27.48±0.49
Grain-filling	24.63±2.34	23.16±0.78	23.34±2.17	22.24±1.20
Full maturity	19.49±1.17	17. 65±1.53	17. 56±0.56	24.26±1.48*

Table 9 Effect of experimental warming and acid rain on nitrate nitrogen (NO_3^--N) in soil of winter wheat/μg·g^{-1}

	CK	T	S	ST
Turning green	68.41±2.20	60.59±6.76	63.49±6.16	69.99±4.39
Elongation-Booting	63.73±0.30	60.62±4.69	62.47±2.62	58.26±1.65*
Heading	54.85±3.57	65.01±6.31*	67.65±4.79**	60.15±0.39
Grain filling	66.89±3.82	69.92±2.96	69.72±4.13	59.01±4.29*
Full maturity	68.64±0.63	56.79±2.95**	62.54±6.52	59.64±1.99*
whole growth period	64.50±0.89	62.59±2.71	65.17±2.36	61.41±1.62

Table 10 Effect of experimental warming and acid rain on total nitrogen (TN) in soil of winter wheat/mg g^{-1}

	CK	T	S	ST
Turning green	1.16±0.03	1.21±0.05	1.15±0.02	1.20±0.03
Elongation-Booting	1.20±0.03	1.12±0.04**	1.03±0.02**	1.05±0.02**
Heading	1.31±0.03	1.28±0.03	1.23±0.03*	1.31±0.03
Grain filling	1.22±0.03	1.19±0.02	1.21±0.03	1.27±0.06
Full maturity	1.09±0.04	1.19±0.04**	1.17±0.01*	1.23±0.02**
whole growth period	1.20±0.02	1.20±0.02	1.16±0.01**	1.22±0.01

5 Conclusions

- T significantly raised mean CO_2 emission fluxes (MCEF) during maturity stage, ST significantly raised MCEF during jointing-booting stage, however, S had no significant difference compared with CK in MCEF.

- ST significantly raised MCEF during flowering-pod stage, however, S and T had no significant difference compared with CK in MCEF.

- Comparing to the control treatment (CK), the T, S and ST treatments all enhanced the N_2O flux and the cumulative amount of N_2O from the winter wheat soil.

- Comparing to the CK treatment, the T and S treatments added the mean N_2O flux from the soil, significantly, but the ST treatment significantly decreased the N_2O flux.

6 Next work

- Impacts of diurnal warming and reduced precipitation on CO_2 and N_2O fluxes from winter wheat and soybean farmland
- Graduation thesis

Thank You