Yale 耶鲁大学-南京信息工程大学大气环境中心

Yale-NUIST Center on Atmospheric Environment

A discussion on the paper "Tunable diode laser measurements of methane fluxes from an irrigated rice paddy field in the Philippines"

I.J.Simpson, G.W.Thurtell, G.E.Kidd, et al.

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Outline

- Background
- Objectives
- Experimental Design
- Results and Discussion
- Summary and Conclusion

Background: Methane

- CH_4 is an important greenhouse gas, The global warming potential per unit mass of CH_4 is 63 times that of carbon dioxide in a 20-year time frame; In addition , CH_4 may be an agent for stratospheric ozone layer depletion.

- The atmospheric CH_4 concentration has been rapidly increasing 160% since the industrial revolution(1750) to 1819 ppb.

- Methane emission from paddy field is one of the major anthropogenic sources of global atmospheric CH_4 emission.however, there were few reports about CH_4 flux measurement in Asia where over 90% of the globle rice are culitivated.

Background:Box Chamber

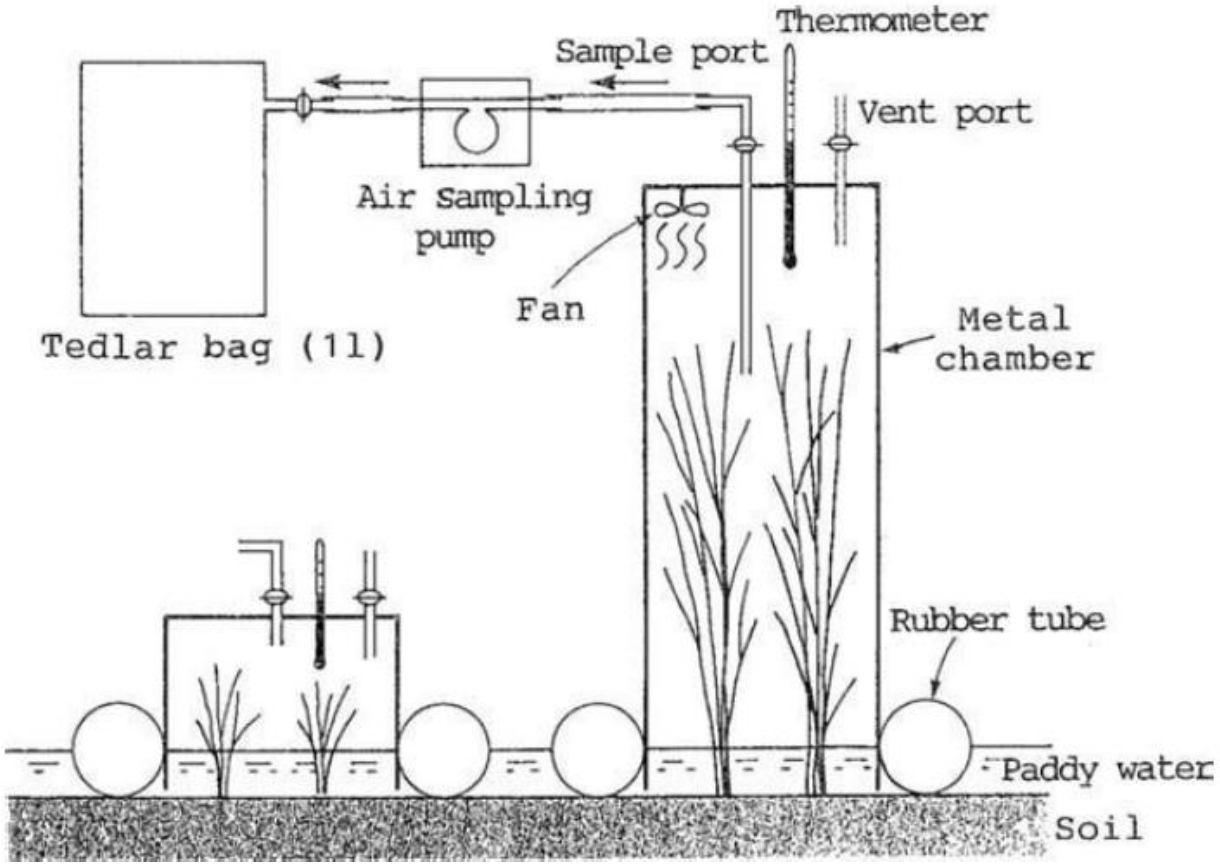

Fig 1 . Schematic illustration of the chambers and the sampling system.

Advantage: **Multi point observation;** Disadvantage: **Bag effects**

New Method: Tunable Diode Laser Trace Gas Analyzer System

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Objectives

- By using TDLAS and the other three micrometeorological techniques, the effects of drying , irrigation and traditional hand weeding experiment on CH_4 emissions were investigated.

- The overall goal of the research is to contribute to the current understanding of CH_4 release from rice paddies and thus help in the search for options to mitigate CH_4 emissions.

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Experimental Design: Sampling Site

Location	14.2° N,121.2° E (Los Banos,Philippines)	Rice seedling	semidwarf rice variety IR72
Area	80m × 100m	Soil	Clayey: PH:6.5 Organic carbon:1.90%
Times	March 9 and 24,1992	Wind direction	northeast

Experimental Design: Floodwater depth

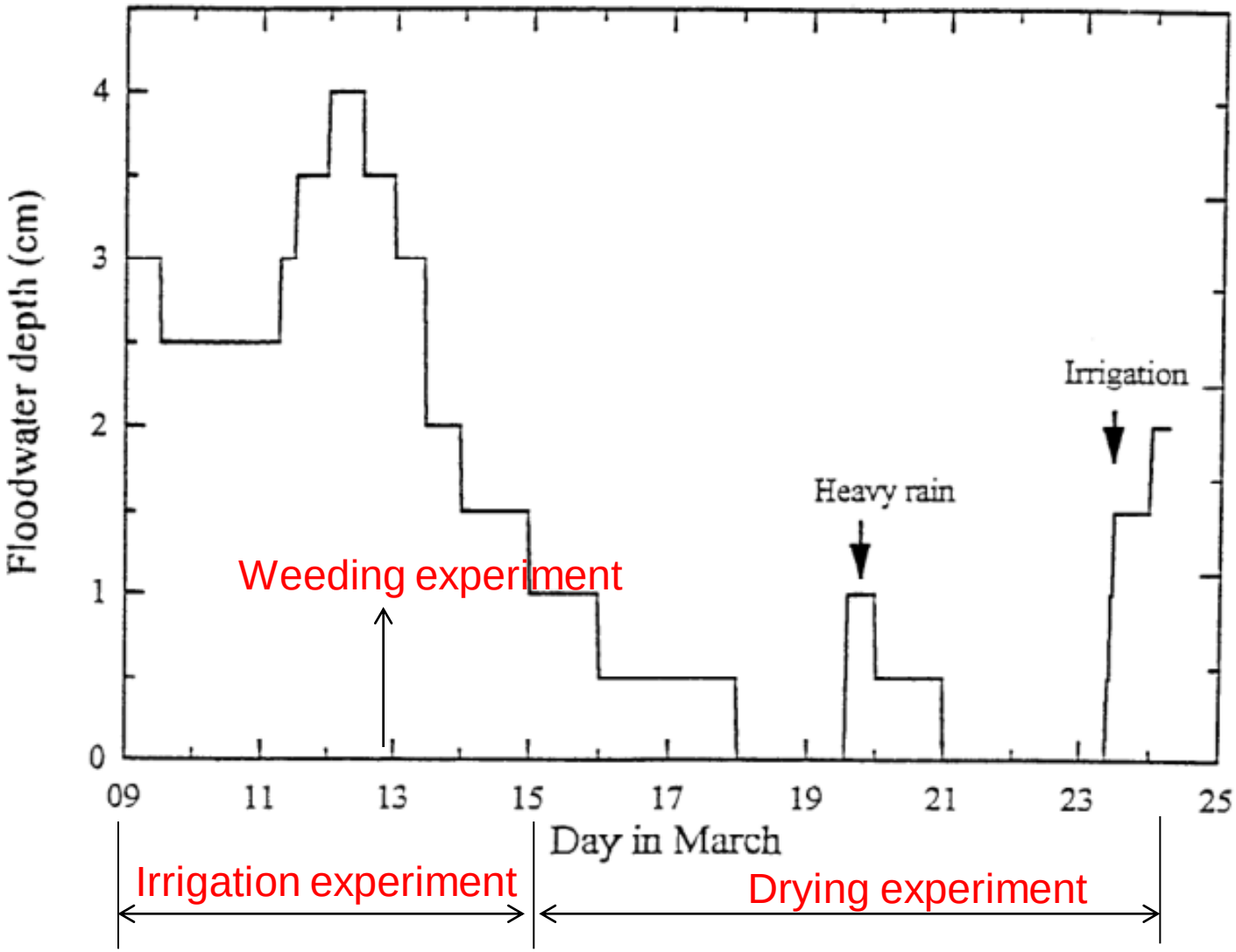

Fig 2 . Rice field floodwater depth changes.

Experimental Design: Method

$$F_{me} = -K(\Delta C_{me} / \Delta z)$$

- F_{me} : flux of CH_4 ($\mu g\ m^{-2}\ s^{-1}$)
- K : eddy diffusivity → { Bowen Ratio; Wind Profile Technique; Eddy Correlation Method }
- ΔC_{me} : change in CH_4 concentration($\mu g\ m^{-3}$) → TGAS
- Δz(m) : vertical height difference

Experimental Design: TDLAS Technique

Tunable diode laser absorption spectroscopy (TDLAS) technique is a new method to detect trace-gas qualitatively or quantificationally based on the scan characteristic of the diode laser to obtain the absorption spectra in the characteristic absorption region.

TGAS parameters

k	2968.4034 cm^{-1}
width	10^{-4} cm^{-1}
laser noise	0.4 ppbv/h
accuracy	>=92%

Experimental Design: TDLAS Technique

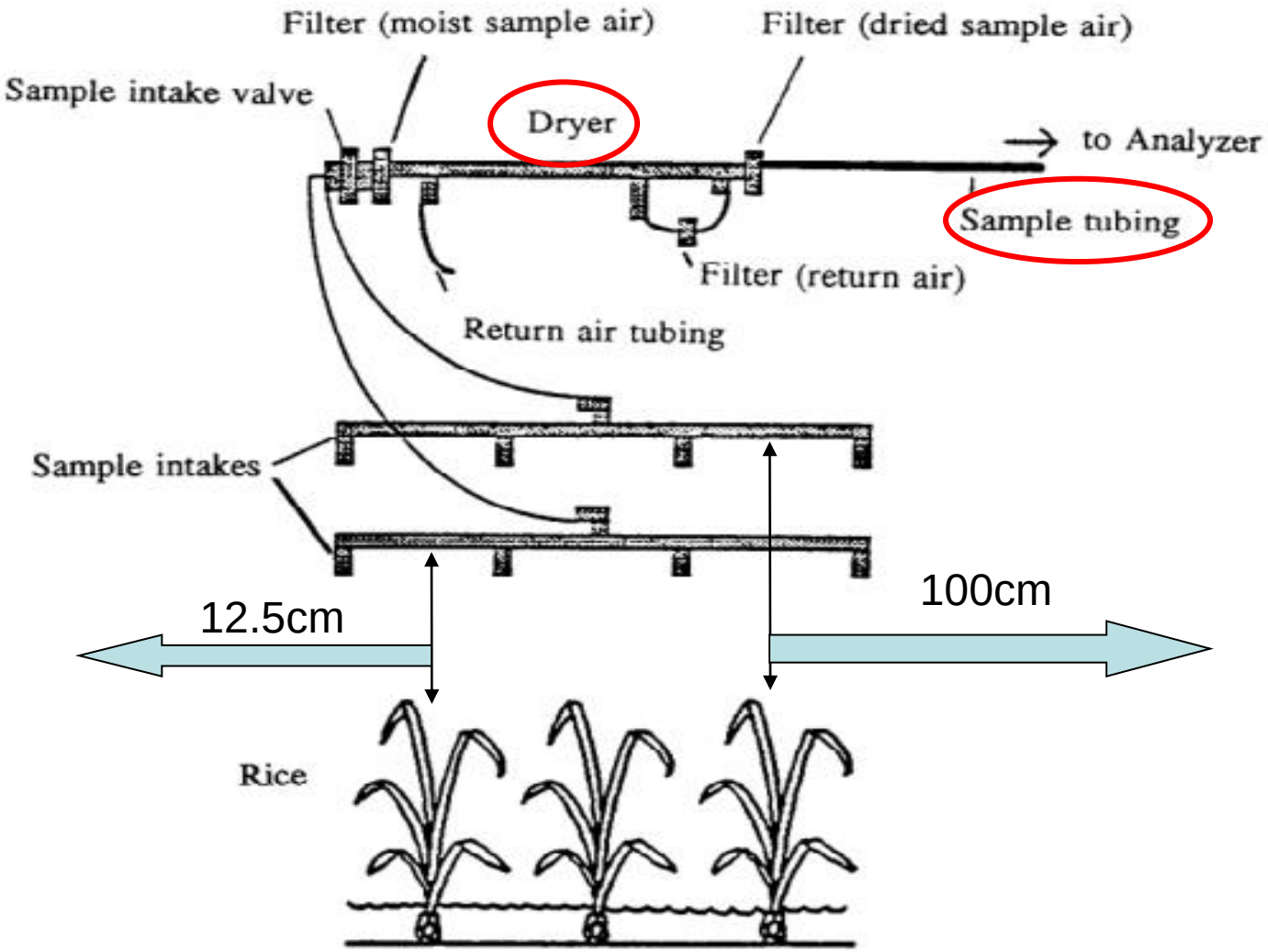

Fig 3 . Field assembly for the trace gas analyzer system(TGAS).[12]

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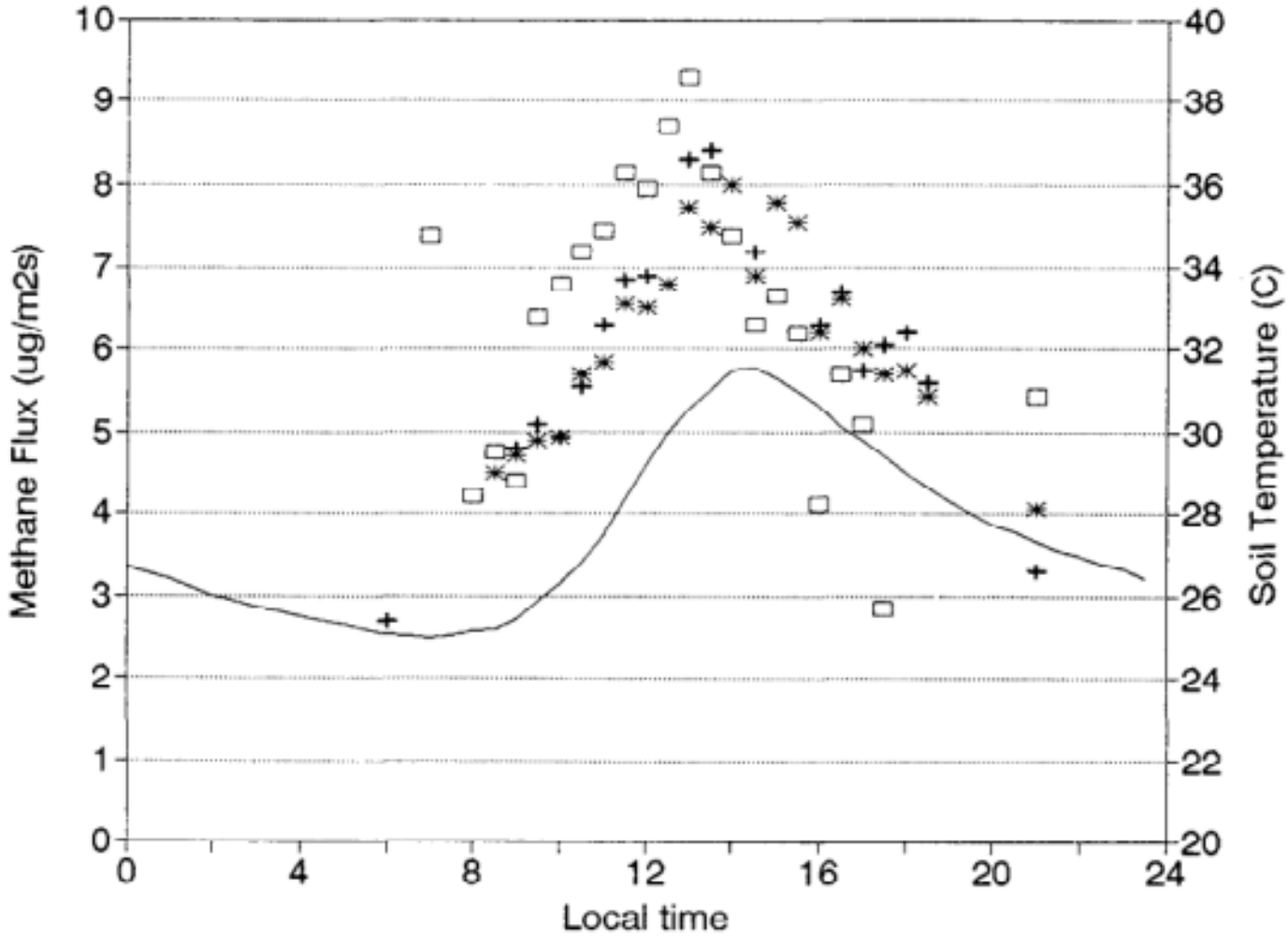
Results and Discussion:Irrigation Experiment



□ Bowen ratio

★ Wind profile

\+ eddy correlation

Fig 4 . CH_4 fluxes generated using Micrometeorological techniques, (March 14).

Results and Discussion:Weeding Experiment

- Up to 80% of CH_4 produced in soils will be oxidized before they can reach the atmosphere.

- Emission pathway:
  - Plant-mediated transport
  - Ebullition
  - Diffusion through the floodwater

Results and Discussion:Weeding Experiment

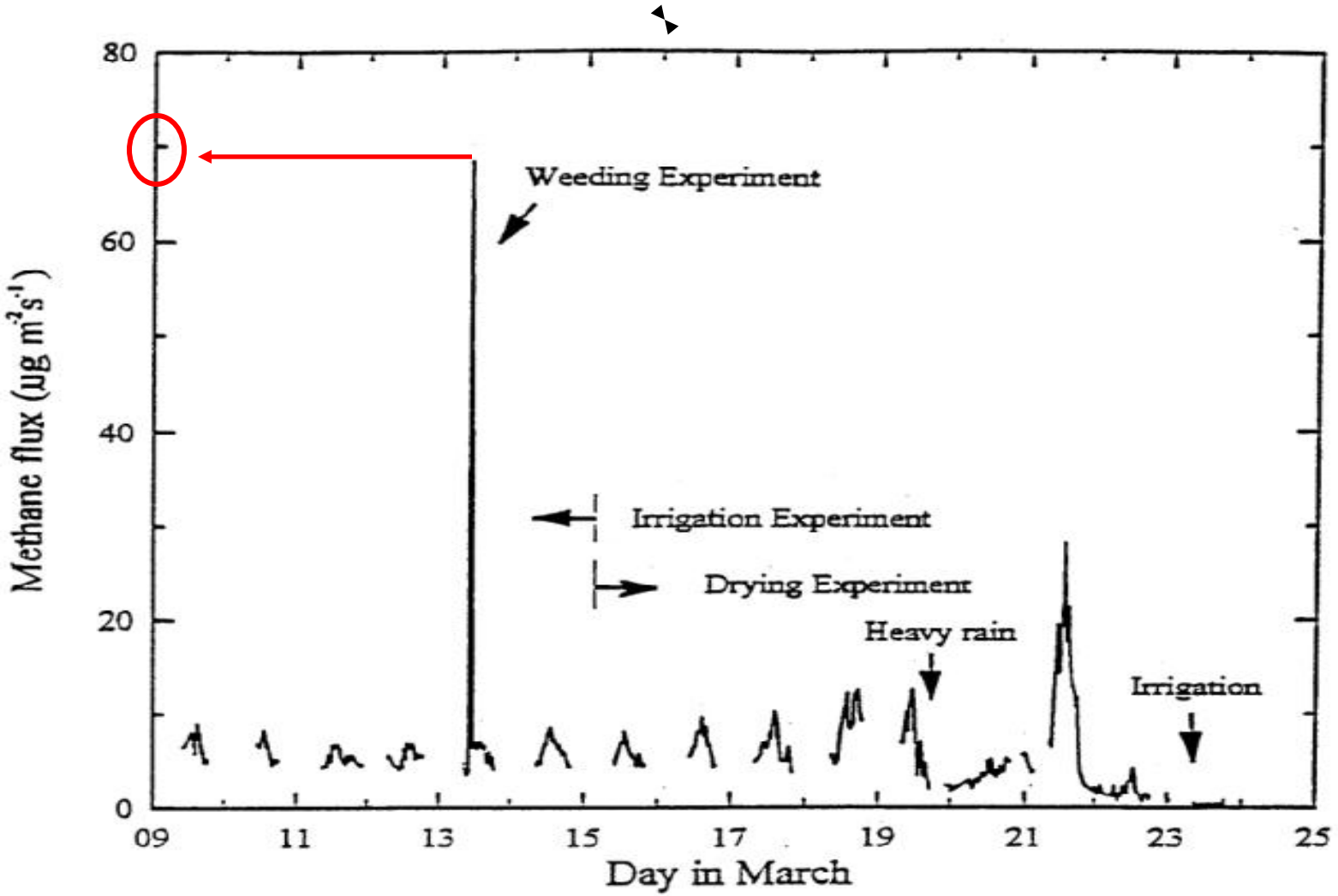


Fig 5. CH_4 fluxes from a rice paddy field during irrigation,**weeding** ,and drying experiments.

Results and Discussion:Drying Experiment

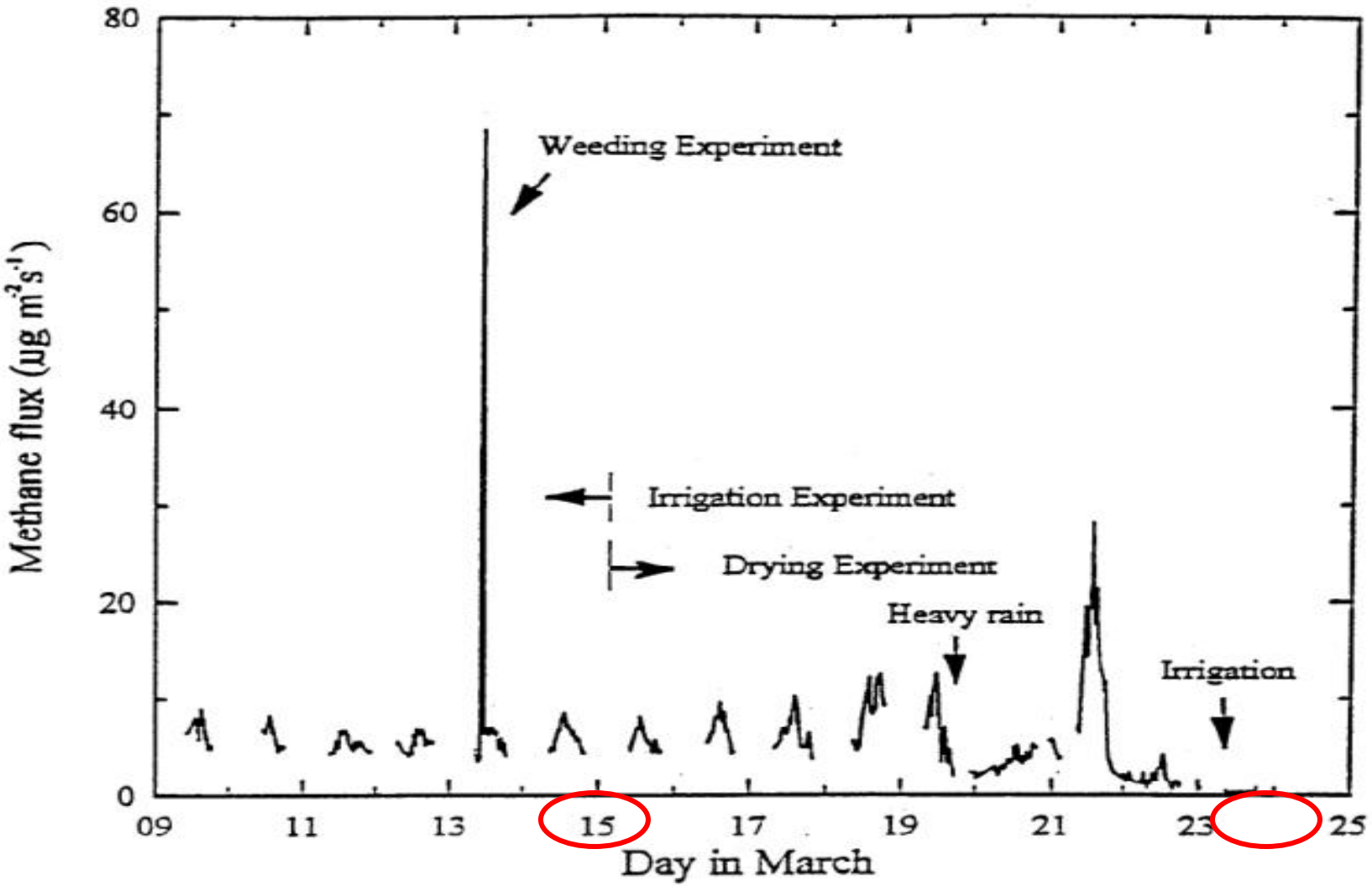


Fig 6 . CH_4 fluxes from a rice paddy field during irrigation,weeding ,and **drying experiments.**

Results and Discussion: Micrometeorological Techniques

Table 1 .Average Daytime CH_4 fluxes Calculated Using Three Micrometeorological Techniques

Technique	Average Daytime CH_4 Flux, $\mu g\ m^{-2}\ s^{-1}$
Bowen ratio	6.22
Wind profile	5.61
Eddy correlation	6.24
Average	6.02 (σ = 0.29)

significance level:α=0.05

1.Daily means of the Bowen ratio fluxes were not statisticaly different from either the wind profile or eddy correlation.

2.The wind profile and eddy correlation means were significantly different.

Results and Discussion: The literature

Table.2.CH_4 Emissions Measured From Rice Paddies

Location	Flux, $\mu g\ m^{-2}\ s^{-1}$	Source
California	2.1	*Cicerone and Shetter* [1981]
Spain	1.1	*Seiler et al.* [1984]
Italy	1.7–4.4	*Holzapfel-Pschorn and Seiler* [1986], *Schütz et al.* [1989a]
Australia	1.1	*Denmead and Freney* [1990]
Japan	0.1–4.2	*Yagi and Minami* [1990]
China	2.2–8.1	*Wang et al.* [1990]
India	0.1–7.6	*Parashar et al.* [1991], *Mitra*, [1992]
Thailand	1.0–5.4	*Houghton et al.* [1992]
Philippines	6.0	micrometeorology; daytime average
Philippines	2.7	box chamber; daytime average

The differences among paddies are caused by some factors:**irrigation,soil characteristics,cultivation history,temperature and season ,measurement techniques**

Results and Discussion: Box Chambers

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The discrepancy between the measured CH_4 fluxes from two adjacent fields prompts us to investigate whether or not micrometeorologocal techniques consistently exceed fluxes measured using the box chamber technique.

Results and Discussion:Reservoir Experiment

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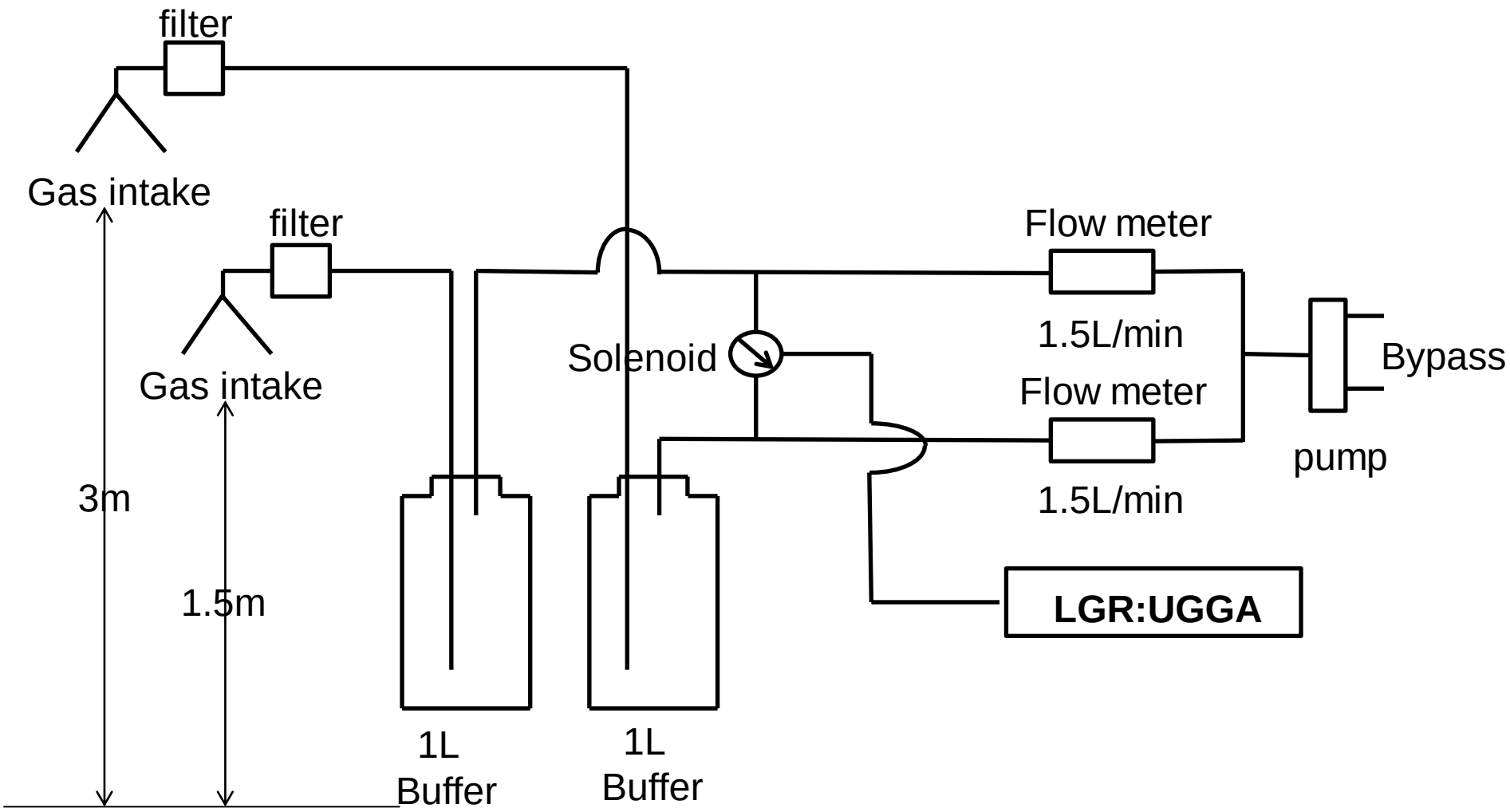

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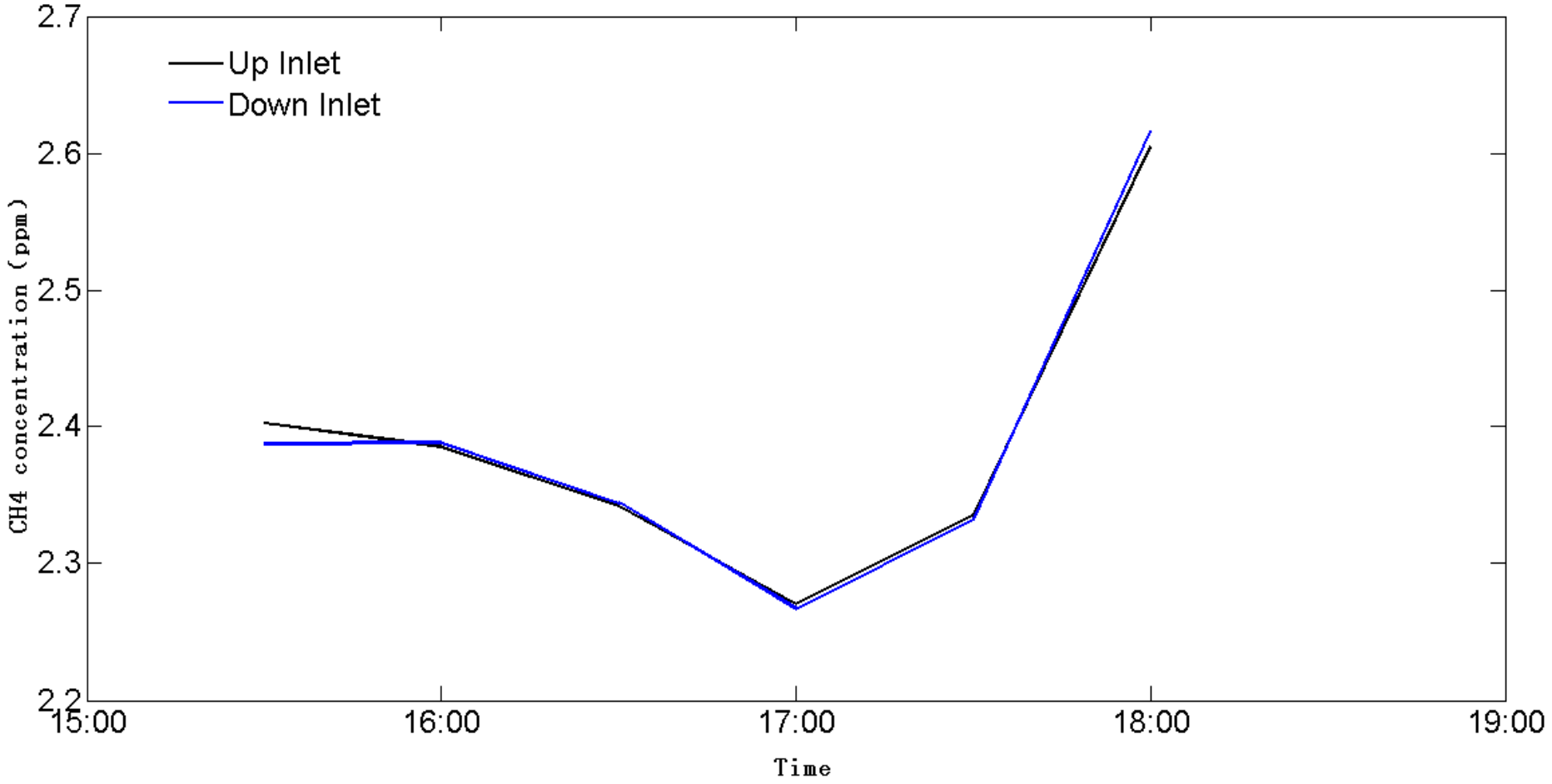

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Summary and Conclusion

Irrigation Experiment: The CH_4 fluxes displayed a diurnal trend similar to the daily soil temperature curves,with peak emissions of about 8 μg m^{-2} s^{-1}.

Simulated Weeding Experiment: A tenfold increase in CH_4 emissions(to about 70 μg m^{-2} s^{-1}) during a brief weeding experiment resulted from soil disturbance.

Drying Experiment: Drying appears to facilitate the release of CH_4 via ebullition and bubble breakage; The CH_4 flux was also arrested when the field was flooded with oxygen-rich water during a heavy rainstorm.

Comparison with Box Chambers: More extensive comparisons of the box chamber and micrometeorological techniques are required to determine whether or not TGAS fluxes consistently exceed those determined by the box chamber technique .

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Thank you