Effect of land use change from paddy rice to upland crop cultivation on methane and nitrous oxide emissions

Seiichi Nishimura1, Takuji Sawamoto2, Hiroko Akiyama1, Shigeto Sudo1, and Kazuyuki Yagi1

1Carbon and Nutrient Cycles Division, National Institute for Agro-Environmental Sciences (NIAES), Tsukuba, Japan, 2Faculty of Dairy Science, Rakuno Gakuen University, Hokkaido, Japan

Contact: snn@niaes.affrc.go.jp (S. Nishimura)

Introduction

Temporal cultivation of upland crops for a few or several years in drained paddy fields is widely conducted in Japan. The area of drained paddy fields for upland crop cultivation is now 740,000 ha, which corresponds to about 30% of the total upland crop cultivation area in Japan.

Dynamic of greenhouse gases may be significantly changed by drainage of paddy soils for upland crop cultivation due to the change in soil physical-chemical and biological properties.

This study:

Methane (CH4) and nitrous oxide (N2O) fluxes were continuously measured and compared among the fields with paddy rice cultivation and those drained for upland crop cultivations.

Materials & Methods

Study site: Experimental field in the NIAES, Japan (34º26’N, 139º47’E) (Fig. 3).

Cropping system: single cropping of paddy rice (PR), single cropping of upland rice (UR) and double cropping of soybean / wheat (SW) (each with duplicated plots).

Measurement of CH4 and N2O fluxes:
Automated closed chamber method (Fig. 2).
Chamber size: 0.9m area, 0.6m / 1.2m height.
Measurement interval: 6 times / day for each chambers.

Results & Discussion

CH4 flux in PR: high during continuously submerged periods, and rapidly decreased after mid-season drainage.

Cumulative CH4 emission in PR: higher in 2003 than in 2002.
--- due to the delayed mid-season drainage in 2003.

CH4 flux in UR: SW: slight absorption throughout the year.

N2O flux in UR: SW: significantly high during the flowering and opening stages of the crops.
--- showing significant influence of the cultivated crops to the N2O flux.

N2O flux in PR: low during most of the rice cultivation periods.

Cumulative N2O emission: by the conversion of paddy rice to upland crop cultivations, increased by 5.5 times.

Summary & Future Studies

Drainage of paddy soils for upland crop cultivation does not increase net GWP by the CH4 and N2O emissions, and may reduce net GWP in paddy fields with high potential for CH4 emission, such as those that are poorly drained or have low soil iron content.

Mechanisms of the N2O production and transport around the flowering to ripening stages of the crops are required to be clarified in the future studies.

For further improvement of the inventory, measurement of greenhouse gas emissions from drained paddy fields with various locations and various kinds of crop cultivations will be required.

Table 1. Cumulative CH4 and N2O emissions and the global warming potentials (GWP) in the croplands with paddy rice cultivations.

<table>
<thead>
<tr>
<th>Year</th>
<th>CH4 (mg CH4 m⁻²)</th>
<th>CH4 (g CO₂ m⁻²)</th>
<th>N2O (mg N m⁻²)</th>
<th>N2O (g CO₂ m⁻²)</th>
<th>Net GWP (g CO₂ m⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>1234</td>
<td>1234</td>
<td>2345</td>
<td>2345</td>
<td>2345</td>
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<tr>
<td>2003</td>
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<td>2345</td>
<td>3456</td>
<td>3456</td>
<td>3456</td>
</tr>
</tbody>
</table>

Net GWP in the PR plots in 2003 (442 g CO₂ m⁻²) was extremely high compared with the other values due to the high amount of CH4 emission.

Combined net global warming potentials (net GWP) by the CH4 and N2O emissions ranged from 70 to 146 g CO₂ m⁻², except for the PR plots in 2003.

Contact: snn@niaes.affrc.go.jp (S. Nishimura)

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