Fertilizer management effect on rice growth and methane emissions in nutrient-deficient lowlands of Madagascar`s highlands

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INTRODUCTION

- Rice, as a staple food for Malagasy people, needs to be increased to meet the population's need.
- Low rice crop productivity is closely related to the low soil fertility, and limited fertilizer inputs including Farmyard manure (FYM) and mineral fertilizer due to the financial situation of them
- Intensification of rice cropping system through fertilizer application increased either rice yield but also CH_4 emission

In this study, we assumed that fertilizer application would increase both rice productivity and CH_4 emissions; and NPK fertilizer is expected to be a potential resilient practice to enhance rice productivity while reducing greenhouse gas emission compared to FYM amendment

METHODS AND MATERIALS

Pot experiment at the Laboratoire des Radioisotopes :
Tested treatments:
- Control : no fertilizer
- Mineral fertilizer: NPK (60 kg N ha^{-1}, 60 kg P ha^{-1}, 60 kg K ha^{-1})
- Organic fertilizer: Farmyard manure (FYM: 10 t ha^{-1}) composition of 160 kg ha^{-1} total N, 2100 kg ha^{-1} total C, and 19 kg ha^{-1} total P content

Field experiment in farmer's field in Behenjy :
Tested treatments:
- Mineral fertilizer: NPK (45 kg N ha^{-1}, 45 kg P ha^{-1}, 45 kg K ha^{-1})
- Organic fertilizer: Farmyard manure (FYM: 10 t ha^{-1})

FYM composition: 150 kg ha^{-1} total N, 2180 kg ha^{-1} total C, and total P content of 27 kg ha^{-1}.

Gas sampling using the closed chamber technique (Minamikawa et al., 2012); CH4 concentration analyzed using a gas chromatograph (GC-14B, Shimadzu, Japan)

RESULTS

Pot experiment

- Higher CH_4 fluxes of NPK during the early rice growth period;

- Higher CH_4 fluxes of FYM during the later growing period (Figure 1);

- Increased grain yield under FYM and NPK by 105.1% and 187.1%, respectively compared to control (Table 1);

-Increased total CH_4 emissions of FYM and NPK by 84.8% and 71.0%, respectively compared to control;

- FYM was 5.7% higher than NPK in terms of total CH_4 emissions;

- NPK showed significantly lower emission intensity than FYM and control.

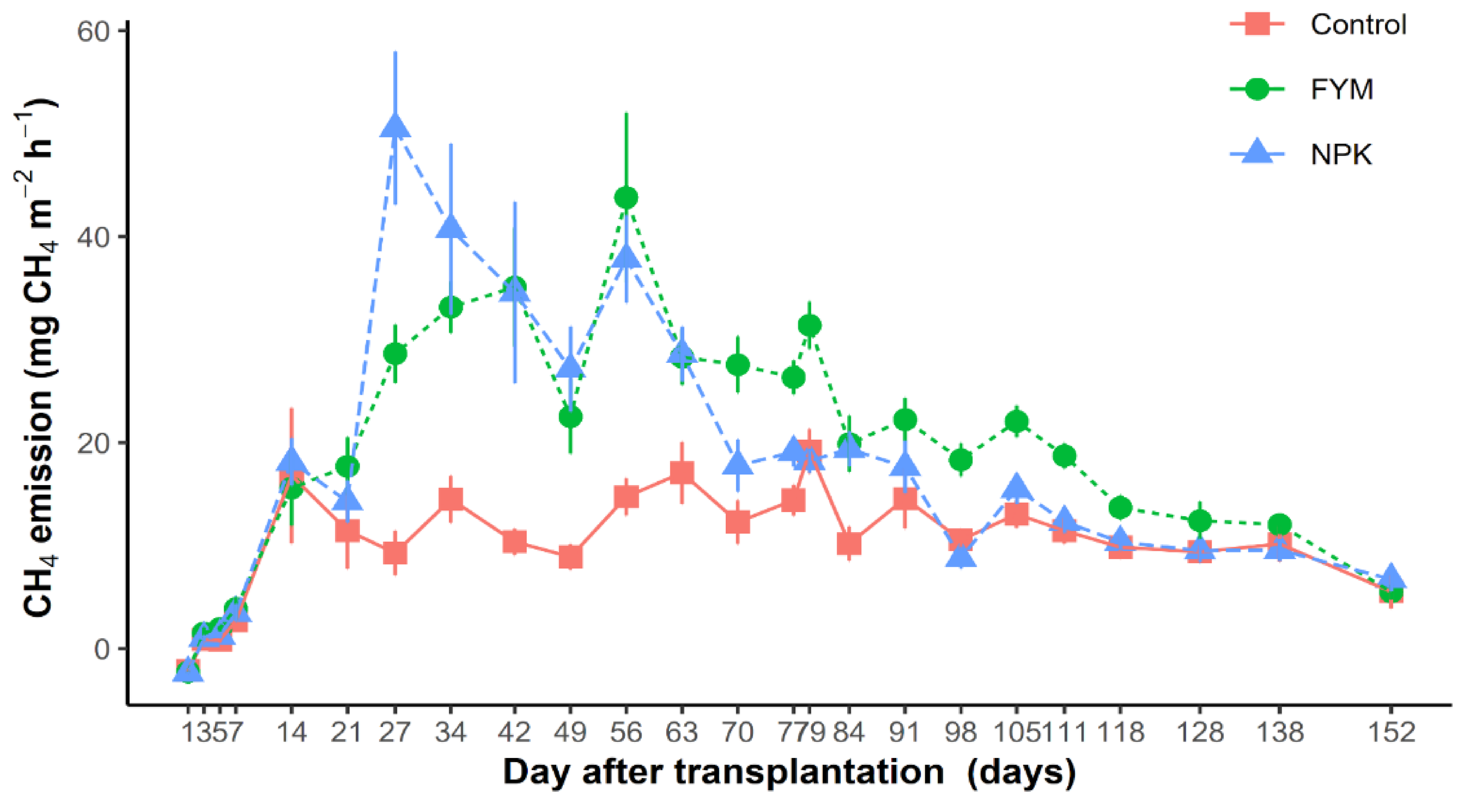

Figure 1. CH_4 fluxes under different treatments in pot experiment (CH_4/m²/h)

Field experiment

- Higher seasonal CH_4 emissions with FYM compared to NPK treatment throughout the rice growth period (Figure 2);

- No significant difference of straw and grain yield between NPK and FYM; although increasing trend of grain yield by 5.7% under NPK compared to FYM (Table 2);

- Similar total CH_4 emissions between NPK and FYM, although decreasing trend of total CH_4 emissions under NPK;

- Increased emission intensity in FYM compared to NPK treatment.

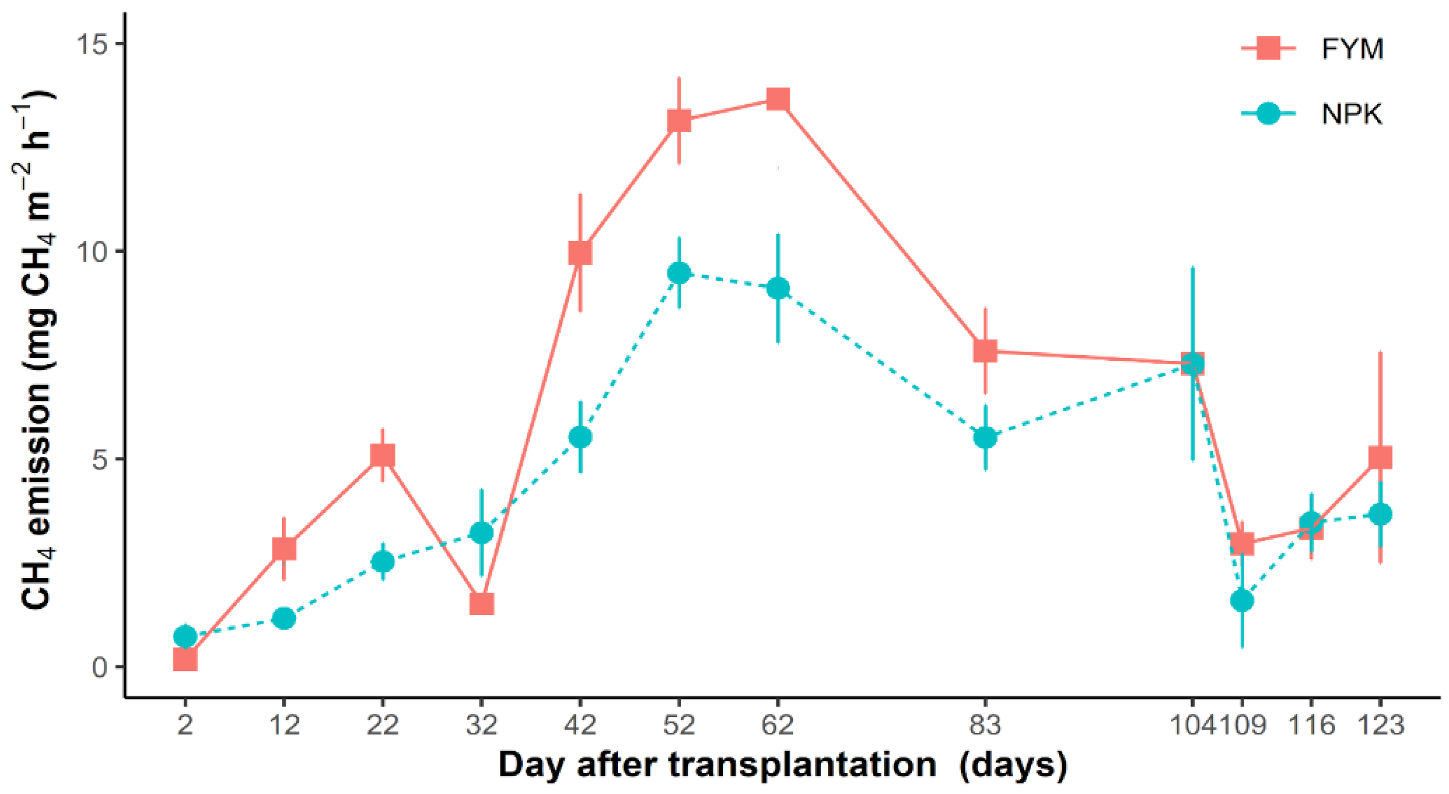

Figure 2 CH_4 fluxes under different treatments in field experiment(CH_4/m²/h)

Table 1. Effect of different treatments on rice yields and total CH_4 emissions

	Straw (g m^{-2})	Grain (g m^{-2})	Total CH_4 (g m^{-2})	Emission intensity (g CH_4 g^{-1} yield)
NPK	815.6a	181.6a	69.2a	0.4b
FYM	582.5b	77.8b	74.8a	1.3ab
Control	284.0c	29.7c	40.5b	1.41a
Treatment	***	***	***	***

Table 2. Effect of different treatments on rice yields and total CH_4 emissions

	Straw (t ha^{-1})	Grain (kg ha^{-1})	Total CH_4 (kg ha^{-1})	Emission intensity (g CH_4 kg^{-1} yield)
NPK	5.2a	4750a	133.5a	27.09a
FYM	4.4a	5020a	185.7a	39.27b
Treatment	n.s.	n.s.	n.s.	*

*Different letters represent significant difference between treatments at $p < 0.05$; n.s.= non-significant; *$P < 0.05$; ***$P < 0.001$*

CONCLUSION

- FYM application resulted the highest CH_4 emissions and lowest rice yield compared to NPK fertilizer

- Higher CH_4 emission from FYM was due to organic amendments imputs which may increase CH_4 production by providing readily mineralizable carbon sources. This effect is more pronounced when organic substrates are added to soils with low organic matter content (Win et al., 2014; Sanchis et al., 2012).

Effective management of NPK fertilizer will be crucial in improving food security while reducing CH_4 emissions and emission intensity from nutrient-deficient lowland rice soils in Madagascar

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