Effects of water saving irrigation managements on greenhouse gas emissions and micronutrients uptake in Philippine paddy soils

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Introduction

The main challenge for global rice research and development in adressing climate change is how to reduce emission of greenhouse gases (GHG) and limit micronutrient deficiency in soils using less water. Specific water management and soil types might play an important role in regulating N_2O and CH_4 emissions and micronutrient availability in paddy soils. This study was conducted to investigate the effect of water-saving irrigation management in rice farming on the GHG emissions and micronutrient availability in three contrasting Philippine paddy soils.

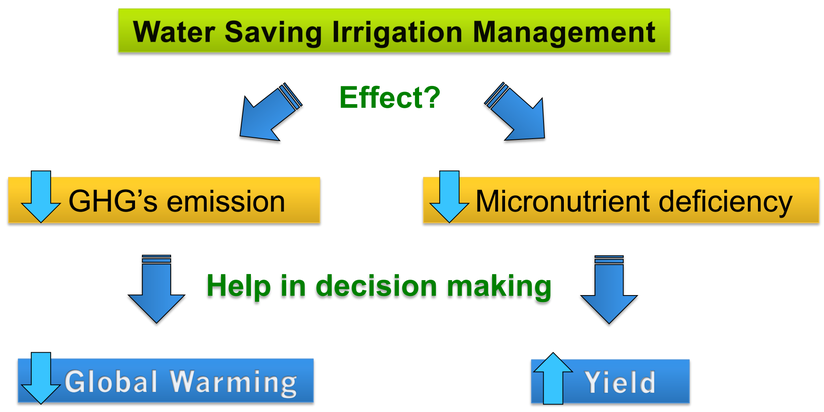


Fig. 1. Research hypothesis

Methodology

1. Experimental design

Randomized Complete Block Design

3 water management:
- CF - Continuous Flooding
- MSD - Mid-Season Drainage
- AWD - Alternate Wet and Dry

3 soil type
- S1 - Silty Clay Loam
- S2 - Sandy Loam
- S3 - Loam

3 replicates

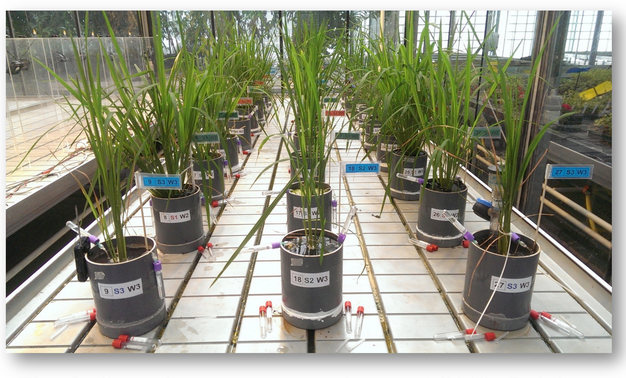


Fig. 2. Greenhouse pot experiment at ILVO, Belgium

2. Analyses

1. Gas
   - N_2O and CH_4

Fig. 3. Gas sampling and Gas Chromatography analyses

2. Soil micronutrients
   - Fe, Mn, and Zn

Fig. 4. DTPA-TEA[1] soil extractions and ICP-OES[2] analyses

3. Agronomic Parameters
   - biomass
   - no. of leaves
   - tiller count

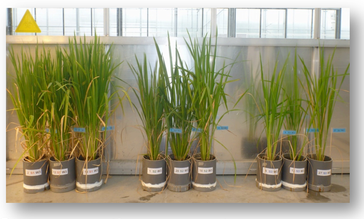


Fig. 5. Crop growth parameter measurement

Results and discussion

1. Greenhouse fluxes

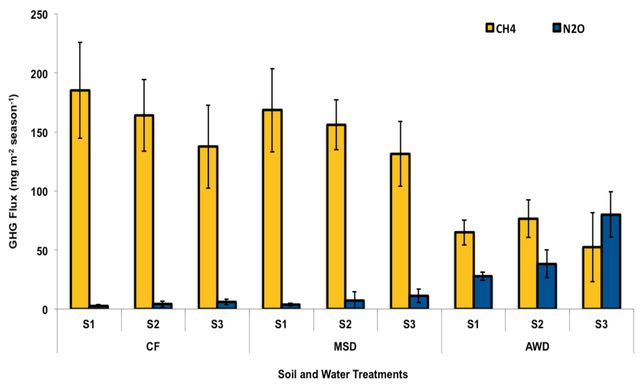


Fig. 6. Averaged GHG emissions under different water treatments in three soils in one growing season

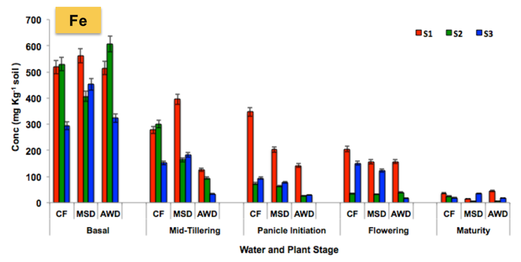
-CH_4 and N_2O fluxes are high at the beginning of the growing season though quickly decline within a time span of three weeks.

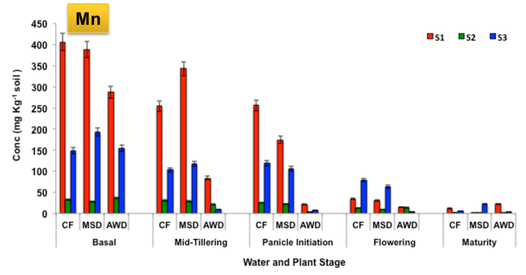
-CH_4 emission increases in the order AWD < MSD < CF in all soil types.

-N_2O emission increases in the order of CF < MSD < AWD in all types of soil.

-Although there was an increase in N_2O in AWD, the amount of methane was still large enough to offset the increase in N_2O.

2. Micronutrients





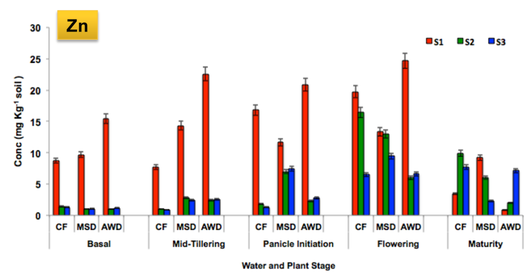


Fig. 7. Seasonal variations in DTPA-extractable (a) Fe, (b) Mn, (C) Zn under different water and soil treatments (error bars represent standard deviation of the mean).

-DTPA-extractable Fe and Mn were more available for the rice plants when CF was employed (negative redox values, results not shown).

-DTPA-extractable Zn was more available under AWD in all types of soils (positive redox, results not shown).

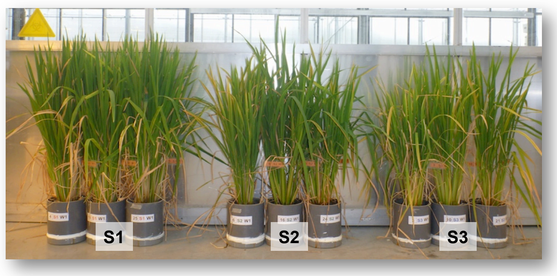
-Reduced availability of Fe and Mn under an AWD compared to CF regime, particularly during the reproductive growth phase of the rice plants. This maybe due to less Fe and Mn reduction under aerobic condition.

-Extractable Zn in three types of soils increased with rice crop growing period. Under AWD and MSD, less SO_4 reduction to S, which can form very insoluble ZnS or by co-precipitation with Mn and Fe in new minerals

3. Plant parameters

Alternate Wet and Dry (AWD)

Mid-Season Drainage (MSD)



Continuously Flooded (CF)

-Rice plant height, tiller and leaf number and mean biomass were all favored by CF when compared to AWD management in all three soils.

-Plants in soil S3 appeared to be less green, had less tillers and less leaves than in soil S1 and S2.

-Plants grown in S1 have the highest plant height, number of tillers and leaves and fresh weight biomass.

Fig. 8. Growth comparison of rice under different water and soil treatments at maturity

Conclusions

- Water saving irrigation management through AWD can help to conserve water and reduce GHG emission.
- Water saving management in rice farming reduces emissions of CH_4, but limit the Fe and Mn availability and uptake for rice.

References

Bouman BAM, Lampayan RM, and Tuong TP. 2007. Water management in irrigated rice: coping with water scarcity. International Rice Research Institute, Los Baños, Philippines.

Johnson-Beebout SE, Lauren JG, Duxbury JM. 2009. Immobilization of zinc fertilizer in flooded soils monitored by adapted DTPA soil test. Commun. Soil Sc. Plant Anal. 40, 1842 -1861.

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[1]**DTPA-TEA** Diethylenetriaminepentaacetic acid Triethanolamine
[2]**ICP-OES** Inductively Coupled Plasma-Optical Emission Spectrometry