POSITIVE FEEDBACK OF CROP RESIDUE INCORPORATION ON DISSOLVED ORGANIC CARBON CONTENTS UNDER ANAEROBIC CONDITIONS IN TEMPERATE RICE PADDY SOILS

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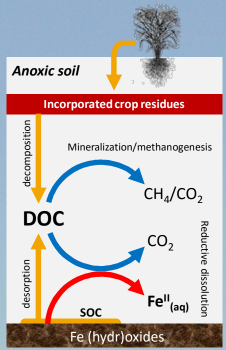
Rationale

Crop residues incorporated after harvest represent the main input of organic C into paddy soils. Their anaerobic decomposition may supply important amounts of DOC. The input of labile organic matter may also stimulate the microbially-catalyzed reductive dissolution of Fe and Mn (hydr)oxides under anoxic conditions, possibly leading to the release of soil-derived DOC previously stabilized on the mineral matrix (i.e. positive feedback). These processes could have important implications on substrate availability for methane (CH_4) production.

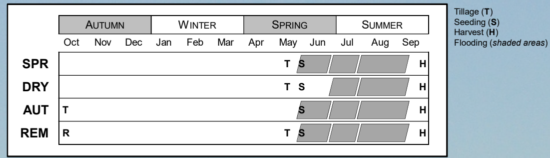


Hypotheses

Crop residue management practices that favour the presence of labile organic matter in the soil at the time of field flooding may enhance: (1) soil solution DOC concentrations, (2) the reductive dissolution of soil Fe and Mn (hydr)oxides, and consequent release of soil-derived DOC, (3) methane emissions.

Experimental design

We tested these hypotheses at field-scale by comparing four crop residue management practices. Over a whole cropping season we evaluated variations in the content and quality (UV abs. at 254 nm) of DOC as well as soil solution concentrations of Fe(II) and Mn, both above (20 cm) and beneath (40 cm) the plough pan. We also evaluated CH_4 emissions by the non-steady state closed chamber method.



SPR
Crop residue incorporation in spring; water seeding

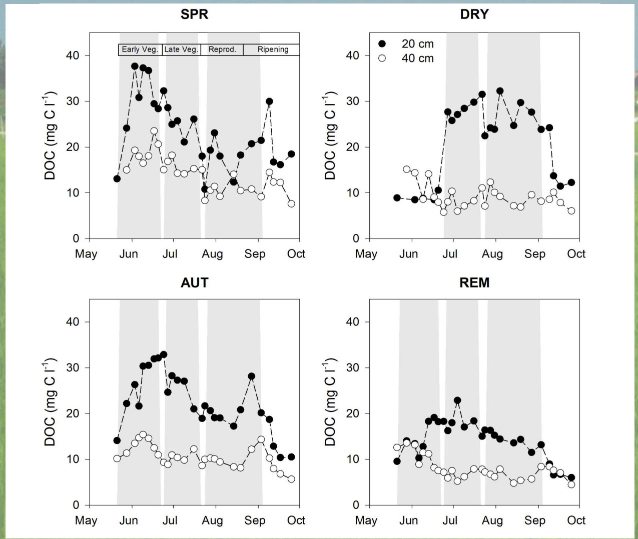
DRY
Crop residue incorporation in spring; dry seeding & delayed flooding

AUT
Crop residue incorporation in autumn; water seeding

REM
Straw removal; crop residue incorporation in spring; water seeding

Results and Discussion

Dissolved organic C



Anoxic soil conditions resulted in an accumulation of DOC in the topsoil across treatments.

In the water seeded treatments, highest DOC contents were generally observed at the beginning of the cropping season, and maximum concentrations varied in accordance with the expected relative input of labile straw-C (SPR ≥ AUT > REM). SPR also showed an important increase in DOC below the plough pan suggesting an important transfer of organic C into the subsoil with respect to the other treatments.

With dry seeding, oxic soil conditions during the early vegetative stage resulted in relatively low DOC contents, that however immediately increased with the onset of flooding.

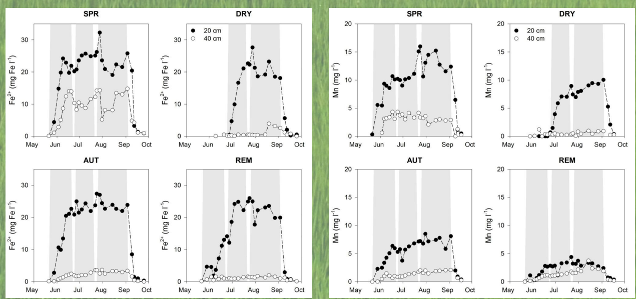
DOC concentrations generally tended to decrease with time except in SPR and AUT, where an increase towards the later stages was observed.

Specific UV absorbance

Treatment	Early veg. stage	Late veg. stage	Reprod. stage	Ripening stage
SPR	4.70	5.75 a	5.53 b	5.64 a
DRY	-	4.26 b	6.02 ab	4.09 a
AUT	4.09	5.55 a	6.39 ab	4.29 a
REM	3.90	6.14 a	7.08 a	4.08 a

Specific UV absorbance (SUVA) values at the beginning of the cropping season suggest an important contribution of residue-derived C to the DOC pool. The increase in aromatic character with time suggests a possible contribution of soil-derived C, as well as a selective mineralization of the more labile DOC components.

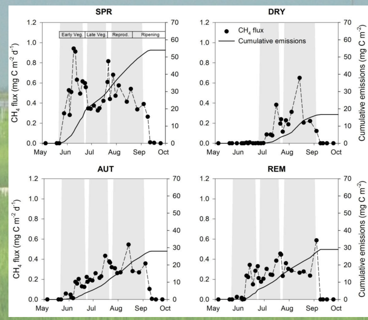
Reductive dissolution of (hydr)oxides

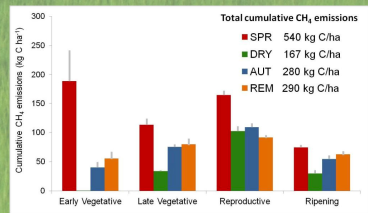


Anoxic conditions during flooding resulted in the reductive dissolution of Fe and Mn (hydr)oxides and consequent release of Fe^{2+} and Mn^{2+} in solution.

The initial rate and extent of (hydr)oxide dissolution generally varied between treatments in accordance with the relative input of labile straw-C (SPR > AUT = DRY > REM).

Methane emissions





Residue incorporation in spring (SPR) resulted in highest CH_4 emissions over most of the cropping season, with peak fluxes measured during the early vegetative and reproductive stage. Reducing the input of labile straw-C by incorporation in autumn (AUT) or removing (REM) led to significantly lower peak and cumulative emissions. Maintaining oxic conditions at the beginning of the cropping season by dry seeding (DRY) delayed the emissions of CH_4, leading to the lowest cumulative emissions among treatments.

Conclusions

The incorporation of crop residue in proximity of field flooding results in high topsoil DOC concentrations, promote C leaching into the subsoil, and favour CH_4 emissions. Our results confirm that under anoxic conditions, the presence of important amounts of labile, residue-derived organic C may result in a positive feedback on the abiotic release of soil-derived DOC by promoting the reductive dissolution of Fe and Mn oxides. Moreover, adopting crop residue practices that reduce the input of labile C or maintain oxic soil conditions for part of the cropping season may serve to mitigate CH_4 emissions.

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