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TC-O_23 GHG emissions from temperate paddy fields under different straw and water managements

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1. Objectives

Straw management is a key factor affecting sustainability of rice cropping systems. Furthermore, rice straw is a potential source for energy production. Straw and water management techniques strongly impact greenhouse gas (GHG) emissions from paddy fields through changes of carbon availability and soil redox conditions that regulate the production and release of both methane (CH_4) and nitrous oxide (N_2O) [1]. Three complementary experiments were established to evaluate the implications of alternative straw and water management techniques on CH_4 and N_2O emissions from paddy cultivation during cropping and intercropping periods.

2. Methodology

Methane and N_2O emissions from temperate rice-cropped soil were measured applying the closed-chamber technique [2] on a series of three experiments established within the Italian rice area (Pavia, Vercelli, and Crescentino, NW Italy) in the period 2012-2014. Three different crop residue management techniques (autumn or spring straw incorporation into soil, straw removal) and three water management practices (continuous flooding, dry seeding and delayed flooding, rotational irrigation) were evaluated. Main details concerning the set-up of the three experiments are provided in Table 1.

Table 1: Main characteristics of the three experiments and short description of treatments.

Experiment	Soil	Type	Duration	Straw Management	Water Management	Fertilization
Castello d'Agogna	Silt-loam, average content of C and N	Field	2 whole years	SPR	Std_FLD	MIN
				SPR	Late_FLD	MIN
				SPR	Rot_IRR	MIN
Vercelli	Silt-loam, average content of C and N	Field	1 cropping season	AUT	Std_FLD	MIN
				SPR	Std_FLD	MIN
				SPR	Late_FLD	MIN
				REM	Std_FLD	MIN
Crescentino	Silt-loam, high content of C and N	Pot	1 cropping season	SPR	Std_FLD	MIN
				REM	Std_FLD	MIN
				SPR	Std_FLD	DG+MIN
				REM	Std_FLD	DG+MIN
				SPR	Std_FLD	DG_SF+MIN
				REM	Std_FLD	DG_SF+MIN

SPR- spring incorporation; AUT- autumn incorporation; REM- removal; Std_FLD- continuous flooding; Late_FLD- dry seeding and delayed flooding; Rot_IRR- rotational irrigation; MIN- mineral; DG- digestate (from maize silage, triticale silage and 5% rice straw); DG_SF- solid fraction of digestate.

3. Results and discussion

3.1 Castello d'Agogna

In Figure 1 yearly cumulative fluxes of CH_4 and N_2O from Castello D'Agogna Experiment, as average of values of 2012 and 2013 campaigns, are shown.

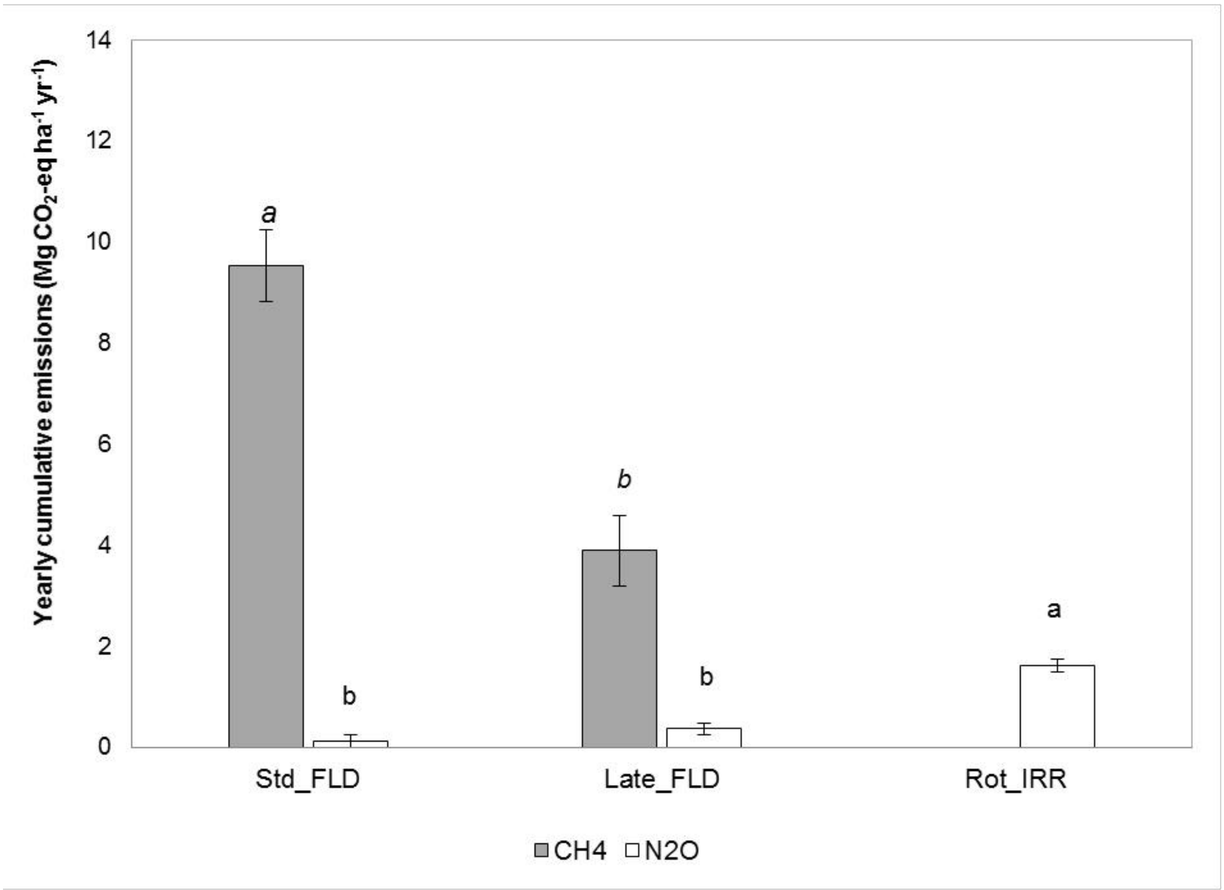

Figure 1: Yearly cumulative emissions of CH_4 and N_2O from Castello D'Agogna Experiment (average 2012-2013).

Reducing conditions, due to flooding, enhanced CH_4 fluxes, leading to the highest emissions in treatments seeded in water and flooded for the most part of cropping cycle [3]. Delaying flooding by approximately one month, not only delayed the beginning of CH_4 emissions but also, significantly reduced their intensity when present, since incorporated straw was subjected to a period of aerobic decomposition and mineralization before flooding. Rotational irrigation on one side prevented any CH_4 loss as oxic conditions prevailed during the whole cropping system, but on the other side induced high N_2O emissions, otherwise limited during flooding due to an inhibition of nitrification and to complete denitrification to N_2. Combining fluxes in the GWP indicator evidenced that CH_4 rather than N_2O is the main contributor to GWP, indicating that continuous flooding had a greater impact on climate change with respect to the alternative water management options.

3.2 Vercelli

Under continuous flooding conditions, autumn incorporation of straw reduced CH_4 emissions with respect to spring incorporation. This is due to the fact that crop residue incorporated in autumn were more degraded (aerobically) with respect to those incorporated in spring at the time of field flooding. The level of emissions produced by treatment AUT was equal to that recorded for REM, showing that early incorporation of straw or its removal was not significantly different for CH_4 budget. Methane emissions being equal, both management options disclose other potentially opposite environmentally friendly properties. In AUT, in fact, incorporated straw can be effective in maintaining proper levels of SOC, while in REM, removed straw could be addressed to a virtuous use of its C for energy production.

Nitrous oxide was produced for all treatments during drainage events, both for favorable redox conditions and for mineral N availability, since all drainage events corresponded to a fertilization

[4]. Yearly cumulative emissions were the highest when straw was removed from field, while were the lowest for autumn incorporation. This behavior suggests straw influences C and N availability that in turn plays a pivotal role in controlling N_2O emissions: on one hand, residue provides a labile C substrate for microbial utilization that can induce N_2O emissions when associated to N fertilization (as happened for SPR-Std_FLD treatment, with respect to AUT); on the other hand soil incorporation of straw induces N immobilization partially preventing N_2O emissions [5].

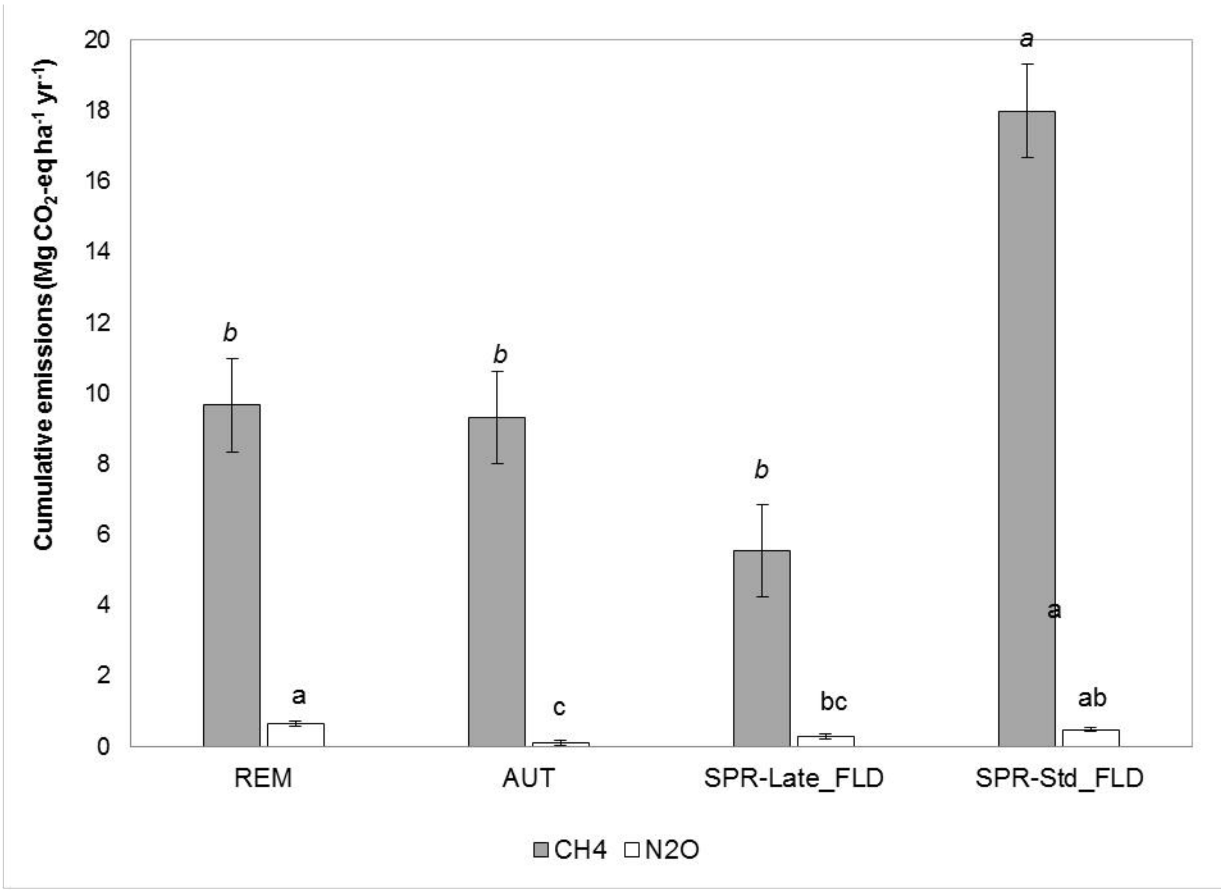

Figure 2: Cumulative emissions of CH_4 and N_2O from Vercelli Experiment (campaign 2014).

3.3 Crescentino

Results showed a significant effect of straw incorporation on CH_4 emissions. When residues were incorporated emission were significantly higher than the corresponding treatment with straw removal, except when only mineral fertilizer was used. The highest emissions occurred in the treatment receiving both straw and solid fraction of digestate, meaning thatCH_4 was driven by the amount of added C [6].

Since the experiment was conducted following a strict protocol and working in pot conditions allowed an optimal control of soil management, flooding was established immediately after fertilization. This resulted in the absence of N_2O emissions during the whole cycle. Combining this information with that arisen from the other two experiments, it appears that correct water management which involves flooding immediately after fertilization can be effective in strongly limiting N_2O emissions.

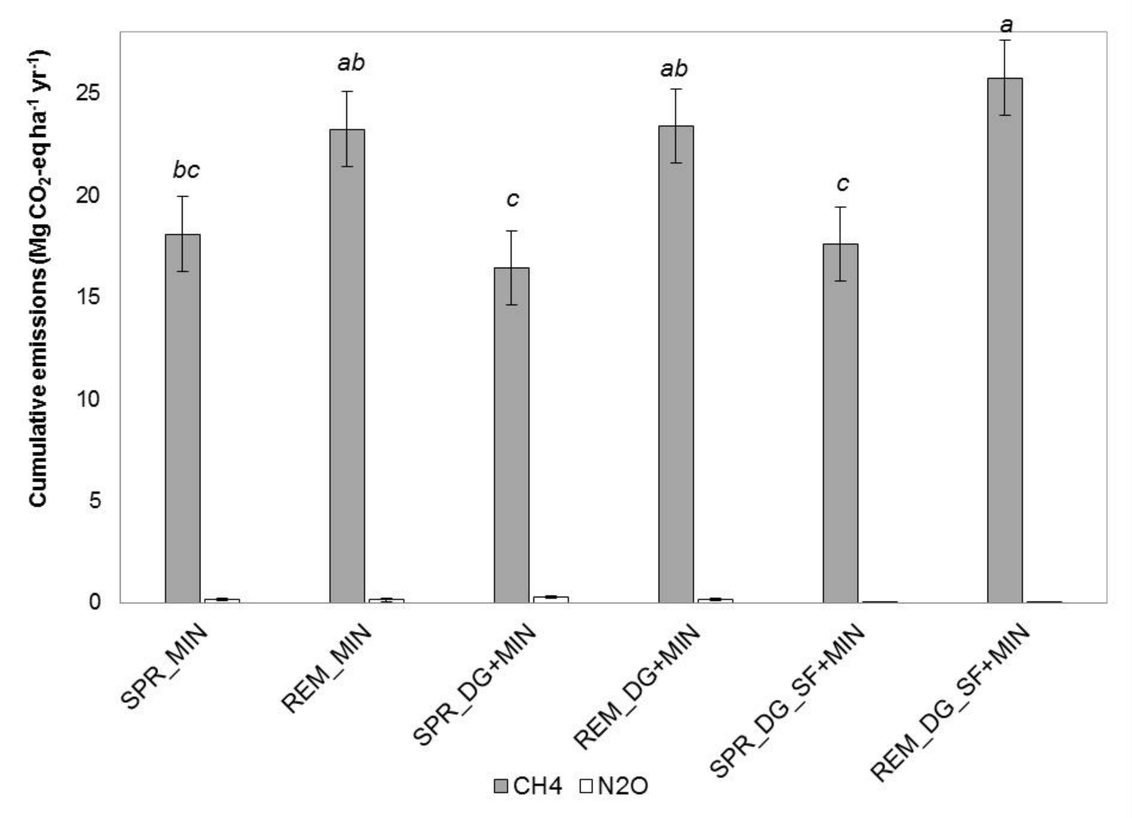

Figure 3: Cumulative emissions of CH_4 and N_2O from Crescentino Experiment (campaign 2014).

4. Conclusion and outlook

The best straw practice for reducing GHG losses was the spring incorporation associated with dry seeding and delayed flooding. Straw removal was effective in reducing field emissions of CH_4. Continuous flooding, although preventing N_2O fluxes, was the water management option showing the worst performance in terms of GHG production, because of enhanced CH_4 emissions.

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