Non-puddled transplanting of rice reduces life cycle greenhouse gas emission

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Introduction

Wetland rice (*Oryza sativa* L.) production contributes 55% of agricultural greenhouse gas (GHG) emissions globally. Hence, any new technology with the potential to reduce the GHG emissions from wetland rice could make a significant contribution to total global warming mitigation by agriculture. Incorporation of conservation agriculture (CA) in the rice–based triple cropping system in the EGP remains a challenge. Measures to reduce CH_4 emissions from rice fields often lead to increased N_2O emissions, and this trade–off between CH_4 and N_2O is a major hurdle in reducing global warming potential (GWP) of wetland rice. Ideal strategies would reduce emissions of both CH_4 and N_2O simultaneously. A novel solution to these constraints for rice production is non-puddled transplanting of rice. The recent development of NP of rice together with residue retention is suitable for CA. A life cycle assessment (LCA) analysis of the new NP rice production technology can estimate its potential contribution to GWP. The present study was carried out to: assess the GHG emissions for conventional puddling and NP with different levels of crop residue retention; determine the hotspots contributing significantly to the GHG emissions within the system boundaries by a LCA study, and identify the causes for the predominant GHG emissions during the pre– and on–farm stages of rice production.

Materials and Methods

Greenhouse gas implications of rice crops were calculated for four establishment practices in the Eastern Gangetic Plains (Durgapur, Rajshahi, Bangladesh): i) conventional puddled transplanting (CT) with low residue retention (LR- current farmer practice for this region which involves keeping about 20% of the standing rice crop residue in the field during harvesting while for other crops like mustard, a complete removal of residues was followed); ii) conventional puddled transplanting (CT) with high residue retention (HR- retention of 50% of standing rice residue and all residues of other crops); iii) non-puddled transplanting (NP) with LR and iv) non-puddled transplanting (NP) with HR. A streamlined LCA approach was adopted, considering cradle-to-farm gate greenhouse gas emissions. A detailed description can be found in Alam et al. (2016).

Results and Discussion

The pre-farm stage in the current study contributed 7-11% of the total GHG emissions. The pre-farm stage produced significantly lower emissions compared to studies conducted in other climates. The lower pre-farm emissions in this study are due to the lower overall level of inputs in comparison with yields obtained, to the use of natural gas as a feed-stock for urea production and electricity generation and to light vehicles for transporting inputs. The contribution of on-farm processes varied between 89 and 93% (in the 100 years horizon) of total GHG emissions. The on-farm GHG emissions from CTLR and CTHR were 91 and 93% of the total emissions while the percentages were 89 and 90% in the case of NPLR and NPHR, respectively. The CTHR contributed the highest on-farm emissions resulting from lower productivity and higher methane emissions. The fuel consumption for irrigation and land preparation and harvesting alone accounted for 14-19% of the total on-farm emissions. Total pre-farm and on-farm emissions from production of 1 tonne of rice in the EGP were 1.11, 1.19, 1.33 and 1.57 tonne CO_2-eq for NPLR, NPHR, CTLR and CTHR, respectively. Contributions to GHG emissions from CH_4 ranged from 60% for NPLR practice to 67% for CTHR practice. This was followed by farm machinery use (13-16%), CO_2 emissions from soil (9-10%), production of inputs (6-9%) and transport of inputs (2-3%). The N_2O emissions account for 2-3.5% of total direct GHG emission for rice production in the Eastern Gangetic Plain. The present study found 0.2 (NPLR) to 0.4% (CTHR) of the applied N fertilizer was emitted as N_2O which is lower than the IPCC default value (1%) of N_2O loss from applied mineral N fertilizer. Most of the produced N_2O might be reduced to N_2 in wetland rice condition. Overall, NP (NPLR and NPHR) offers greater GHG saving (29%, 24% over CTHR and 18%, 16% over CTLR) relative to the CT method. More specifically, NPLR had the highest reduction potential for on-farm emissions due to emission of least CH_4.

Conclusions

The novel minimum tillage establishment approach for rice involving strip tillage followed by non-puddled transplantation has potential to increase global warming mitigation of wetland rice in the EGP plains. We recommend conducting additional LCA for all the crops of the rice-based cropping system to assess the GWP of the CA practices in diversified rice growing areas.

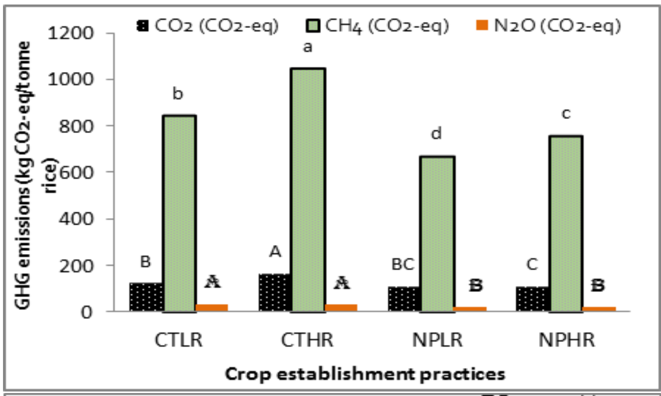

Figure 1. Effect of rice establishment techniques and residue retention on on-farm emission of GHG (CO_2 equivalent; $p < 0.05$). Bars with the same letter above are not significantly different at $p < 0.05$. SE (±) for CO_2 emission is 4.7; for CH_4 43.5 and for N_2O 0.2 over 100-year time horizons, respectively.

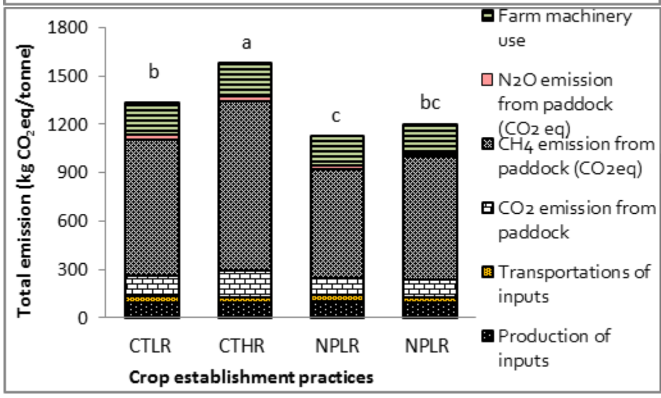

Figure 2. Total GHG emissions (CO_2 equivalents) in terms of inputs and outputs for one tonne of paddy production as influenced by crop establishment techniques and residue retention. [Legend: CT–puddled transplanting and NP–non-puddled transplanting; LR–low residue retention and HR–high residue retention]

References

Alam, M.K., Biswas, W.K., Bell, R.W. 2016. Greenhouse gas implications of novel and conventional rice production technologies in the Eastern-Gangetic Plains. *J. Cleaner Prod* 112, 3977–3987, doi: 10.1016/j.jclepro.2015.09.071.