Greenhouse Gas emission from Agricultural Wetland (Rice Field): Organic vs. Conventional farming

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Introduction

- The agricultural sector is one of the major anthropogenic sources of greenhouse gases (GHGs), particularly of methane (CH_4) and nitrous oxide (N_2O).
- Agricultural wetlands (e.g. rice fields) may act as an important source for GHGs due to global prevalence, periodic flooding schedules, high use of high analysis nitrogenous fertilizers and burning of crop residues in agricultural fields.
- Organic farming presents a valid alternative approach to conventional farming due to it's potential to contribute quite substantially to the global food supply, while reducing the detrimental environmental impacts of conventional agriculture.
- Consequences of agricultural greenhouse gas fluxes to management practices (crop, fertilization, soil management) is still unclear .
- This study compares the GHGs emission response of two agricultural management practices.

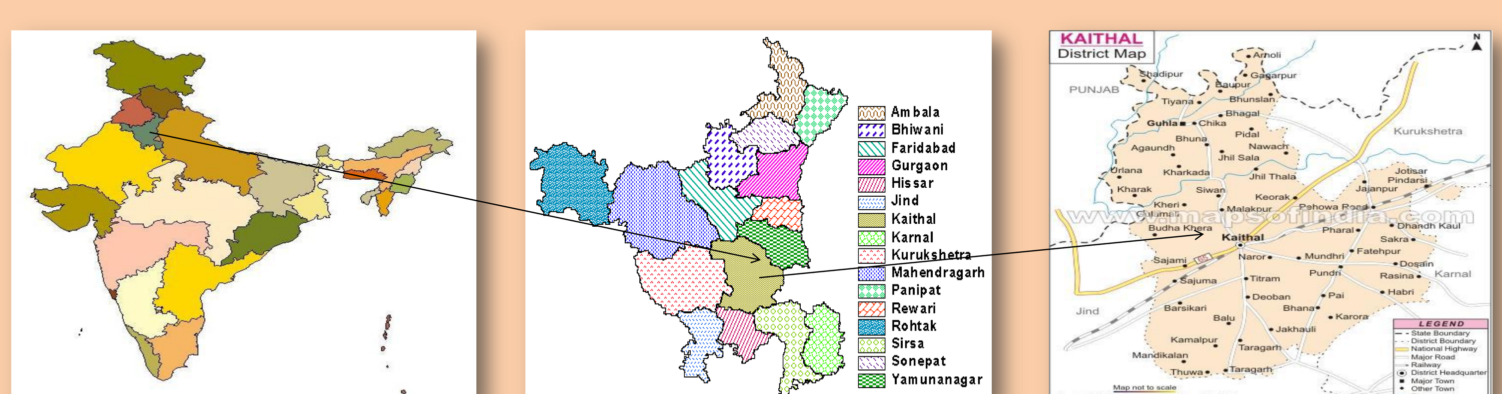
Hypothesis

- Organic agriculture offers a major potential to reduce the emissions of agricultural GHGs through restoring soil organic matter content .

Objective

- To estimate potential GHGs emission of organic farming compared to conventional system of basmati rice cultivation by InfoRCT simulation model.

Materials and Methods



India Haryana Kaithal

Fig.1: Map of study area

- The study was conducted during *kharif* season (July to October) of 2009 at Kaithal district of Haryana, India (Fig. 1).
- The study area comprised of 7 organic and 7 conventional fields spread over six villages in Kaithal, where organic farming is practiced for last 9 years.

Table 1. Soil Physico-chemical properties of the study area

Farming Practices	Texture	pH (1:2.5)	Electrical Conductivity (dS m^{-1})	Organic C (%)	Kjeldahl N (kg ha^{-1})
Organic	Sandy loam	8.27	0.33	0.57	259.4
Conventional	Sandy loam	8.31	0.47	0.39	236.06

InfoRCT model information

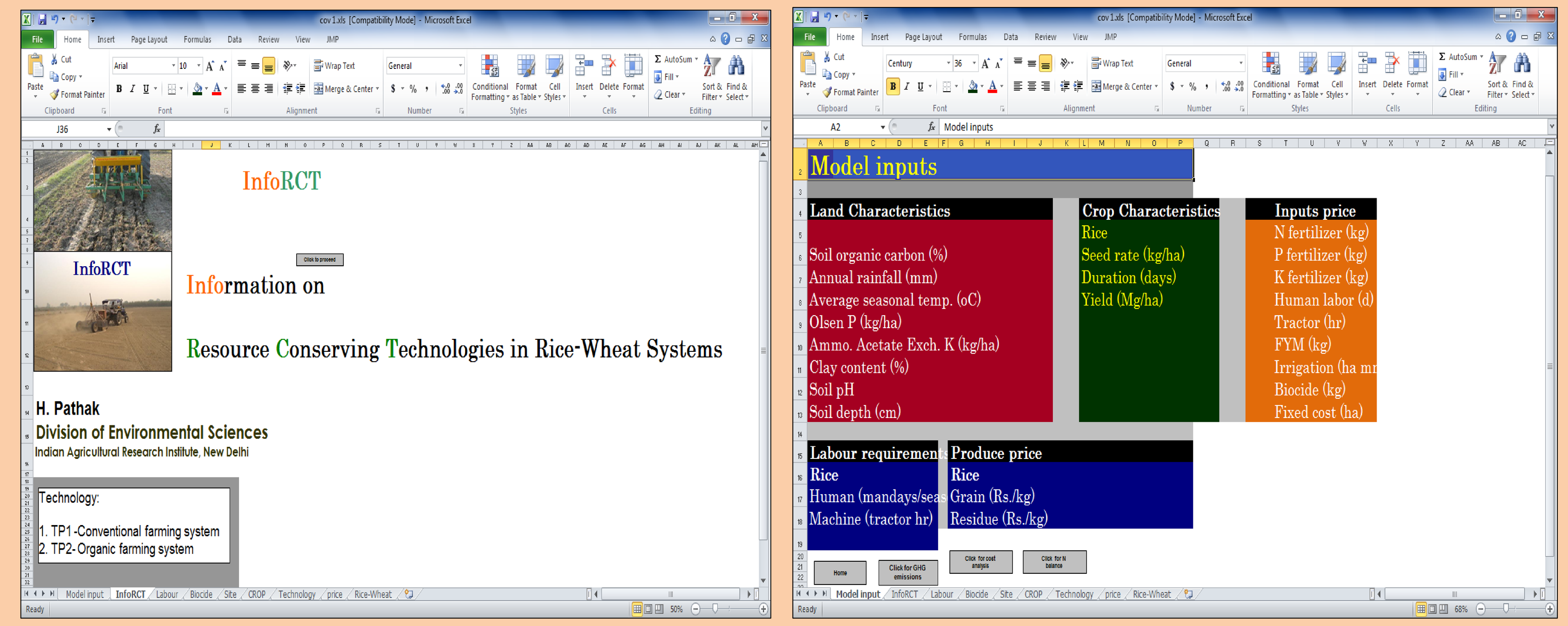


Fig. 2: InfoRCT simulation model

- Potential GHGs emission estimated with the help of a decision support system (DSS), named InfoRCT (Information on Use of Resource Conservation Technologies in Agriculture) (Fig. 2).
- The DSS integrates analytical and expert knowledge on biophysical, agronomic ,and socioeconomic features to establish input output relationships related to water, fertilizer, and biocide uses and GHGs emission in the rice-wheat system.
- InfoRCT consider agricultural GHGs emission from several sources (e.g. agricultural soil, farm operations, off-farm operations and applied nitrogenous fertilizer).

Results and Discussion

- To gain an insight into the effects of soil properties on the GHGs emission from both practices, multiple regression analysis of CH_4 and N_2O emission is performed against Kjeldahl N, soil enzyme activities and OM.

Table 2. Prediction equations relating measured soil parameters to simulated GHGs (CH_4 and N_2O) emissions (n=42).

Regression equation to predict CH_4 emission (kg CO_2 eq. ha^{-1})		
Simulated GHGs emission	Measured soil parameters	R^2
$CH_{4Organic}$	2203 -1.48 Kjeldahl N***+0.09 DH***+0.07 AP*** + 0.006 FDA*** + 13.15 OM***	0.99
$CH_{4Conventional}$	608.4-2.15 Kjeldahl N+0.21DH*+0.29 AP*- 0.003 FDA-12.94 OM	0.43
Regression equation to predict N_2O emission (kg CO_2 eq. ha^{-1})		
$N_2O_{Organic}$	64.5 + 0.007 Kjeldahl N + 0.003 DH*** - 0.004 AP-0.0002 FDA + 0.49 OM***	0.86
$N_2O_{Conventional}$	- 22.83 + 0.007 Kjeldahl N - 0.003 DH+0.014 AP + 0.0007 FDA + 0.09 OM	0.32

*** Significant at 0.001 probability
* Significant at 0.5 probability level
Measured soil parameters used in the prediction equations are- **Kjeldahl N** (kg ha^{-1}), Enzyme activities like **DH**= Dehydrogenase (mg TPF g-1 dry soil hr^{-1}) , **AP**= Alkaline Phosphatase (mg PNP g-1 dry soil hr^{-1}), **FDA**= Fluorescein di-acetate hydrolysis(mg Fluorescein g-1 dry soil hr^{-1}) and **OM**= Organic matter(%).

- Dehydrogenase enzyme activity and OM appeared to significantly contribute to GHGs (both CH_4 and N_2O) emission from organic system, while Kjeldahl N, Alkaline Phosphatase, Fluorescein di-acetate hydrolysis made contribution only to CH_4 emission from organic system at 0.001 level of significance (Table 2).
- Significant differences (*α=0.001*) of Dehydrogenase enzyme activity and OM indicate that GHGs emission from organic system increased with increase in activity of Dehydrogenase enzyme and OM content.

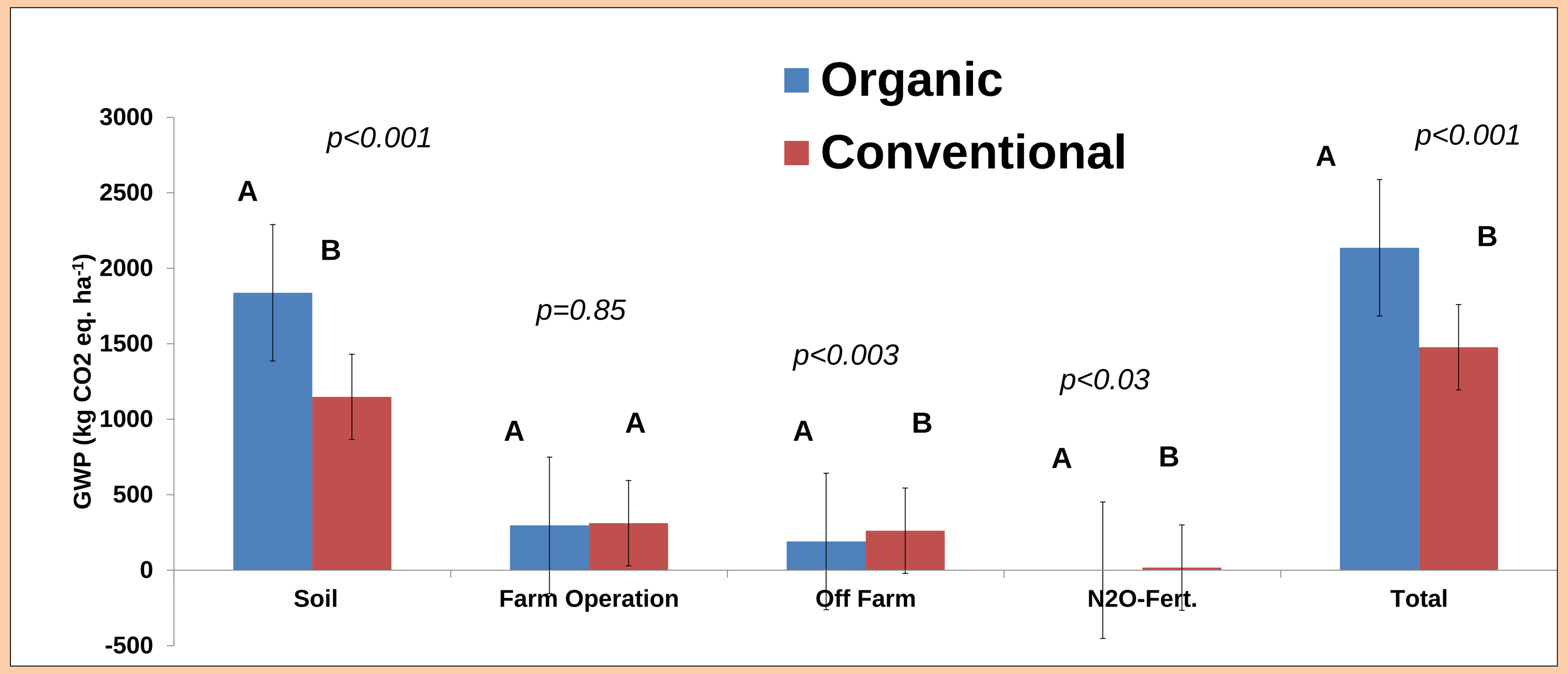


Fig. 3: Simulated global warming potential (GWP) in organic and conventional systems.
Different letters represent significant differences between means for two farming practices at 5 % level of significance. Data are shown means (n=42; ±SE of mean).

- $GWP_{soil}= CH_4*25 + N_2O*298$, $GWP_{Farm-operation}= CO_2*1$, $GWP_{Off-farm\ operation}=CO_2*1$, $GWP_{N2O-Fert}=N_2O*298$
- $GWP_{Total}= GWP_{soil} + GWP_{Farm-operation} + GWP_{Off-farm\ operation} + GWP_{N2O-Fert}$

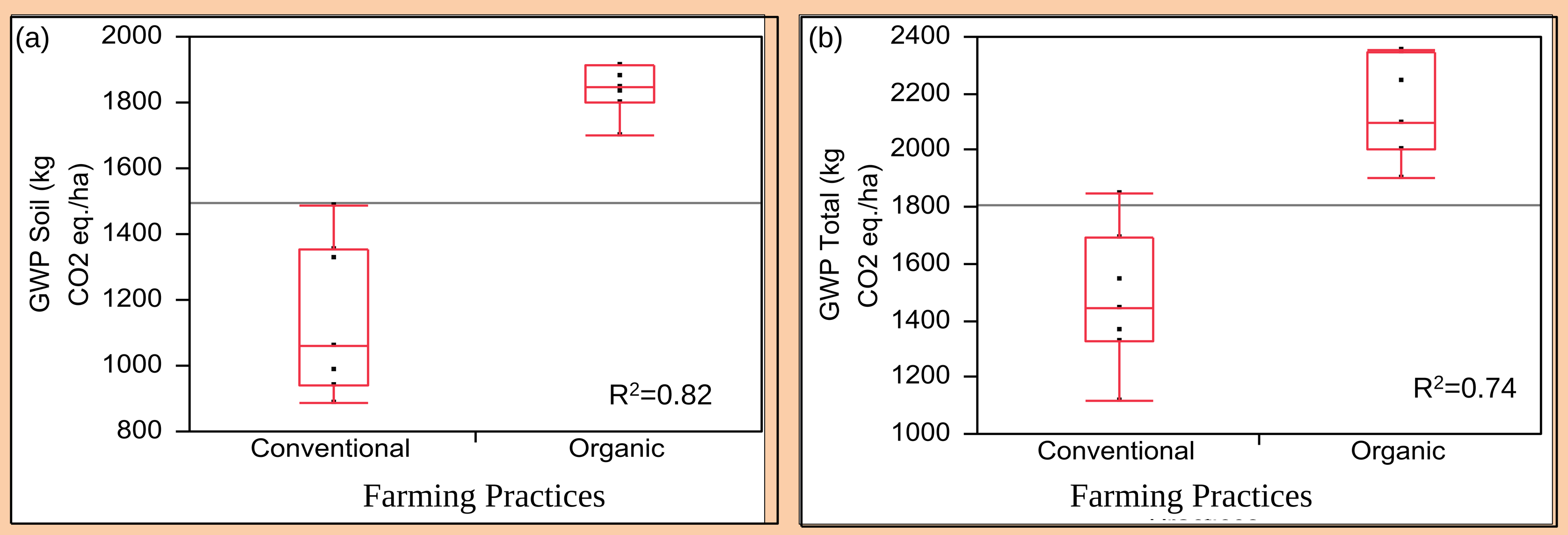


Fig. 4: Oneway Analysis of GWP soil (a) and Total GWP (b) by Farming Practices.

- Though global warming potential (GWP) due to farm operations, off farm operations and nitrogenous fertilizer application were higher in conventional system, total GWP was higher in organic systems (2135.5 kg CO_2 eq. ha^{-1}) as compared to conventional systems (1477 kg CO_2 eq. ha^{-1}) (Fig. 3).
- Soil accounts for the major contribution in total GWP in both farming practices (Fig. 4) thus plays a key role in GHGs emission from agricultural wetlands (e.g. rice).
- Soil GWP in organic systems stands for methane (CH_4) emissions from agricultural soils and excludes nitrous oxide (N_2O) emission from nitrogenous fertilizer.
- Application of manures in organic fields enhances CH_4 emission by adding organic carbon and N required for growth of methanogenic archaea.
- Additionally, organic matter in the form of organic manure also serves as a source of electrons creating more anaerobic conditions and higher CH_4 emission.

Conclusions

- GHGs emission increased due to increase in Dehydrogenase activity and OM in organic system.
- Higher OM in organic fields enhanced CH_4 emission from soil due to increased anaerobic condition.
- The findings suggest that agricultural wetlands especially organic rice fields may be important hotspots for GHGs emission, and warrant additional research.