Life cycle assessment of corn-based cropping system with and without cover crop

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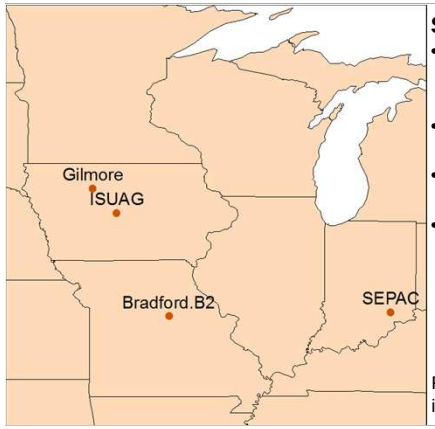
INTRODUCTION

Including a small grain winter cover crop during the fallow period in the corn-soybean rotation has the potential to reduce soil & nutrient losses, soil trace gas flux and build soil organic matter. The cover crop, however, requires additional field operations and inputs, which lead to up-stream emissions and additional cost. The study objective is to analyze and evaluate the environmental trade-offs of including rye cover crop in the corn-soybean rotation from a life cycle perspective, and to compare the trade-offs both within a single site and across the study sites in different geographical locations.

Four experimental sites were analyzed. In the treatment with cover crop; rye was planted after both corn and soybean and terminated two weeks before the planting of the main crop without removing any residue. The analysis was performed by a cropping-system based "cradle to gate" LCA tool with the field edge as its system boundary. The uncertainty of the LCA was assessed through Monte Carlo Simulation.



Site Descriptions:

- Gilmore city, IA. Clay loam soil, top soil SOC ≈ 3.3%
- ISUAG, IA. Silty clay loam soil, top soil SOC ≈ 2.7%
- SEPAC, IN. Silt loam soil, top soil SOC ≈ 1.5%
- Bradford.B2, MO. Silt loam soil, top soil SOC ≈ 1.7%

Figure.1 Experimental sites included in this study

MATERIALS & METHODS

❖ Life Cycle Impact Categories

- Crop Productivity (crop yield)
- Environmental Impacts (Soil loss, nutrient loss, GHG emissions)
- Non-renewable Energy Use

❖ LCA Uncertainty Analysis

- Sensitivity Analysis
- Monte Carlo Simulation

RESULTS & DISCUSSION

❖ Sensitivity Analysis

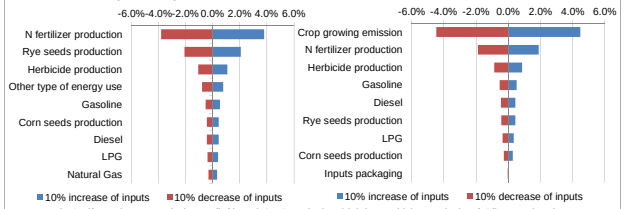
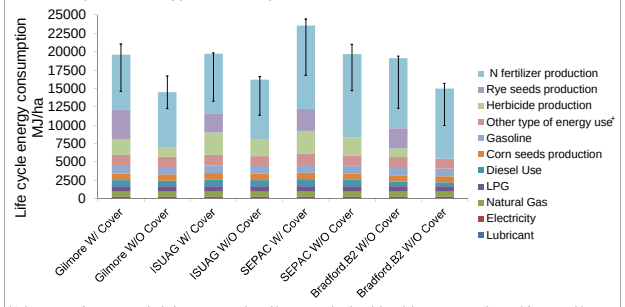


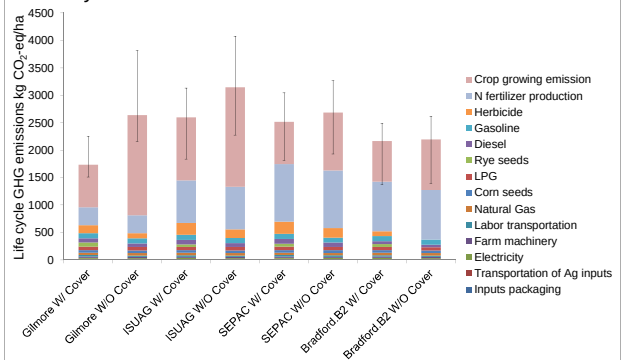
Fig.2 Life cycle energy balance (left) and GHG emission (right) sensitivity analysis of Gilmore city site.

❖ Life cycle energy consumption



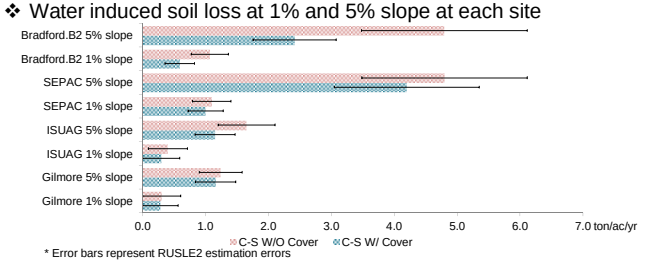
*Other types of energy use include: transportation of inputs, packaging, labor, labor transportation and farm machinery.
*Error bars represent the life cycle analysis uncertainty

❖ Life cycle GHG emissions



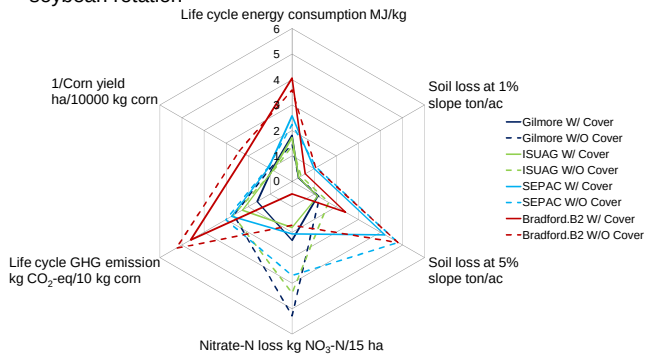
* Error bars represent the life cycle analysis uncertainty, data presented are for 2011 only

❖ Water induced soil loss at 1% and 5% slope at each site



* Error bars represent RUSLE2 estimation errors

❖ Environmental trade-offs of including winter cover crop into corn-soybean rotation



CONCLUSION

- The environmental trade-offs of growing cover crop is site dependent, cover crop effectively reduced nutrient loss and GHG emissions in Iowa, while more important in controlling soil loss in Missouri and worked fairly well in reducing nutrient loss, soil loss and GHG emissions in Indiana.
- The use of nitrogen fertilizer was recognized as a key contributor in both life cycle energy balance and GHG emissions at all sites, which highlights the importance of adopting robust site-specific N-management strategies.
- Additional field operations and inputs associated with cover crop have led to more life cycle energy consumption and cost. Government cost-sharing or subsidies might be needed to motivate wider adoption cover crop.
- More data are needed to appropriately calibrate and validate the DAYCENT model .

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