Life cycle impacts of a corn-soybean system with and without cover crop

Lei Gu[1], Robert Anex[1], Eileen Kladivko[2], Matthew Helmers[3], John Sawyer[4], Peter Scharf[5]

[1] Department of Biological Systems Engineering, University of Wisconsin-Madison
[2] Department of Agronomy, Purdue University
[3] Department of Agronomy, Iowa State University
[4] Department of Agricultural and Biosystems Engineering, Iowa State University
[5] Division of Plant Sciences, University of Missouri

INTRODUCTION

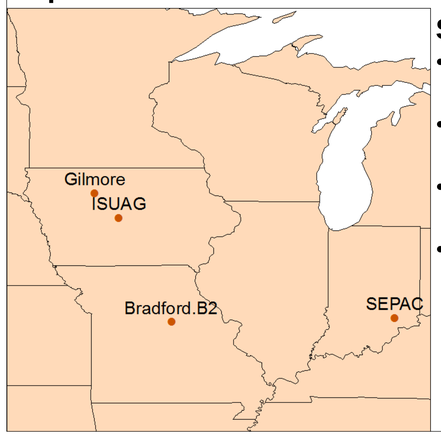
The objective of this study is to assess the life-cycle environmental trade-offs of including a winter rye cover crop in the corn-soybean rotation from a life cycle perspective, and to quantify the trade-offs of using a cover crop in different geographical locations.

We studied a no-till corn-soybean rotation with and without cover crops at four experimental sites. Winter cereal rye was planted immediately after both corn and soybean harvest and terminated two weeks before the planting of the main crop without removing any residue. The analysis includes "upstream" impacts (e.g., energy used to make fertilizer). Impacts analyzed include: crop yield, energy balance, trace gas fluxes, nutrient loss, and soil erosion.

METHOD AND APPROACH

Life Cycle Assessment Framework

Experimental Sites

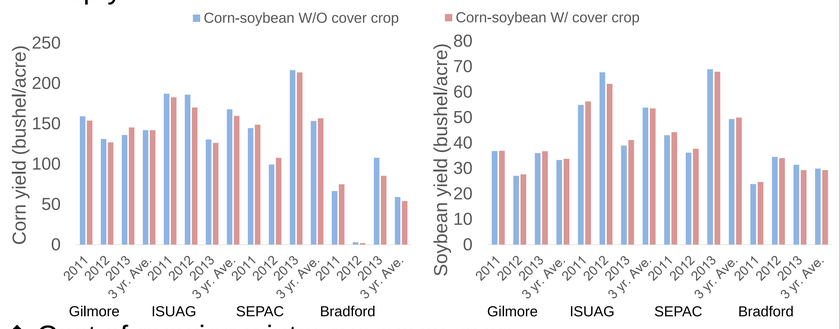


Site Descriptions:

- 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%

RESULTS AND DISCUSSION

❖ Crop yield



❖ Cost of growing winter rye cover crop

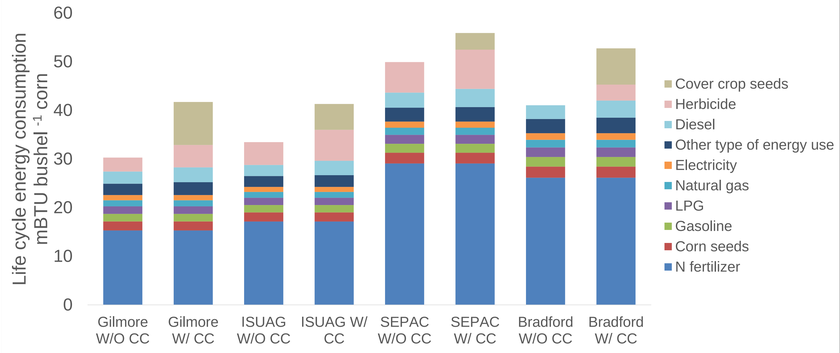
Herbicide Sprayer	Small Grain Drilling	Cover Crop Seeds	Glyphosate	Total Cost
$/ac				
2.00 ~ 18.00†	6.00 ~ 30.00†	10.20 ~ 31.13‡*	2.32 ~ 9.82‡*	20.52 ~ 88.95

† The cost of field operations (e.g., spraying and drilling) include the cost of fuel and labor. The ranges are summarized from multiple source: (1) NASS, 2013. Wisconsin custom rate guide 2013; (2) Iowa State University Extension, 2014. 2014 Iowa farm custom rate survey, file A3-10b; (3) University of Missouri Extension, 2012. 2012 custom rates for farm services in Missouri G302; (4) Michigan State University Extension, 2013. 2014 Custom machine and work rate estimates, fire team fact sheet 13-06; (5) Ohio State University Extension, 2012. Ohio farm custom rates 2012, AEDE 11-12.

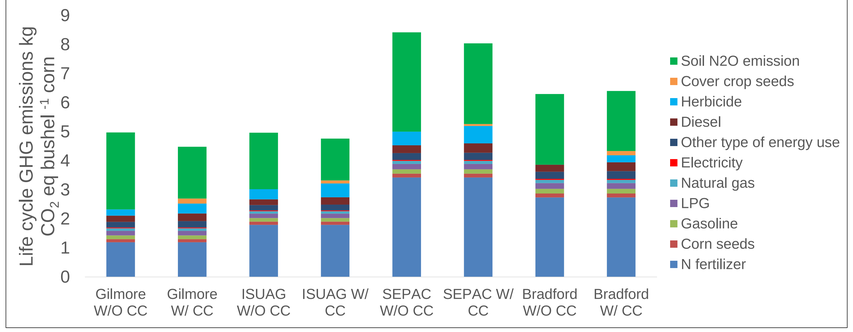
‡ Singer, J. 2011. Cover crops: Why, How and How Much? The seeding cost and herbicide cost were of $0.125/lb and $0.083/oz, respectively.

* Cover crop seeding rates (81.6 ~ 249.1 lb/ac) and herbicide application rates (28 ~ 118.3 oz/ac) are experimental data from the Sustainable Corn Team.

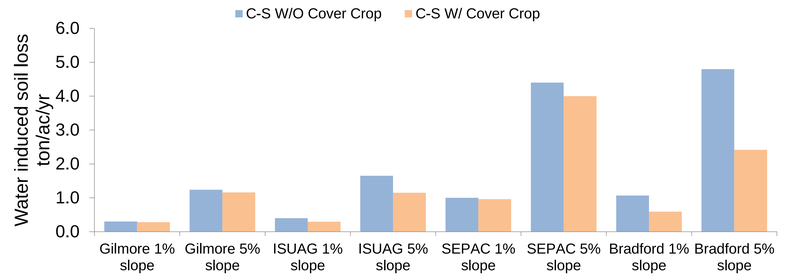
❖ Life cycle energy consumption



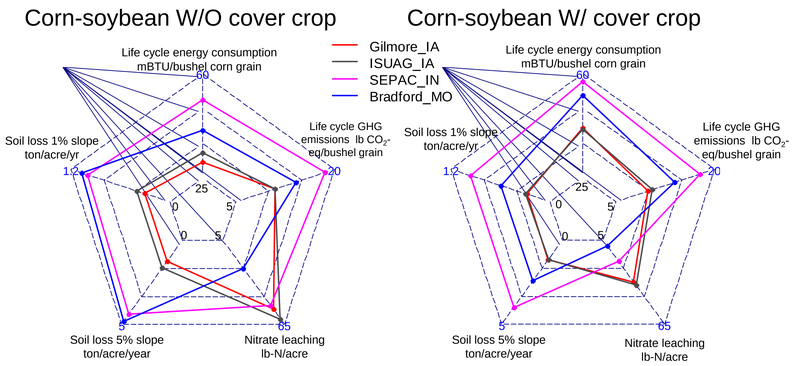
❖ Life cycle GHG emissions



❖ Soil erosion



❖ Life cycle trade-offs



CONCLUSION

- Winter cereal rye cover crop can provide multiple environmental benefits without affecting cash crop yield at 5% significance level.
- Including winter cover crops in crop rotations is promising for reducing soil loss, nutrient loss and trace gas emissions, but the effectiveness of cover crops varies from site to site depending on climate, soil conditions and crop productivities.
- Environmental trade-offs are site dependent: cover crop reduced nutrient loss and GHG emissions in Iowa, was more effective in controlling soil loss in Missouri, and reduced nutrient loss, soil loss and GHG emissions in Indiana.
- Approximately 946 - 2136 MJ/acre (0.9 - 2.0 mmBTU/acre) of energy were consumed by the additional field operation and inputs associated with the management of cover crops.
- The nitrogen fertilizer use is as a key contributor to both life cycle energy use and GHG emissions at all sites, highlighting the importance of adopting robust site-specific N-management strategies.
- Study does not account for longer-term impacts of changes in soil condition or extreme weather.

Biological Systems Engineering
UNIVERSITY OF WISCONSIN-MADISON

This research is part of a regional collaborative project supported by the USDA-NIFA, Award No. 2011-68002-30190 "Cropping Systems Coordinated Agricultural Project (CAP): Climate Change, Mitigation, and Adaptation in Corn-based Cropping Systems" sustainablecorn.org

SUSTAINABLE CORN.ORG
CROPS, CLIMATE, CULTURE AND CHANGE

USDA
United States Department of Agriculture
National Institute of Food and Agriculture