Simulating long-term impacts of cover crops and climate change on crop production and environmental outcomes in the Midwest

Andrea Basche[1]
Fernando Miguez[1]
Sotirios Archontoulis[1]
Thomas Kaspar[2]

1. Iowa State University Department of Agronomy
2. National Laboratory for Agriculture and the Environment

Rationale

- Evaluating conservation practices that protect soil and water resources from climate change in the Midwest, where one-third of global maize and one-quarter of global soybeans are produced, is critical to cope with climate risks.
- An over winter cover crop, given its ability to reduce erosion and sequester carbon, can reduce some of the anticipated changes for the Midwest, such as increased rainfall variability and rising temperatures.

Objective: Quantify the impact of a winter rye cover crop on corn and soybean yields, soil carbon, erosion and nitrous oxide emissions, with future climate change.

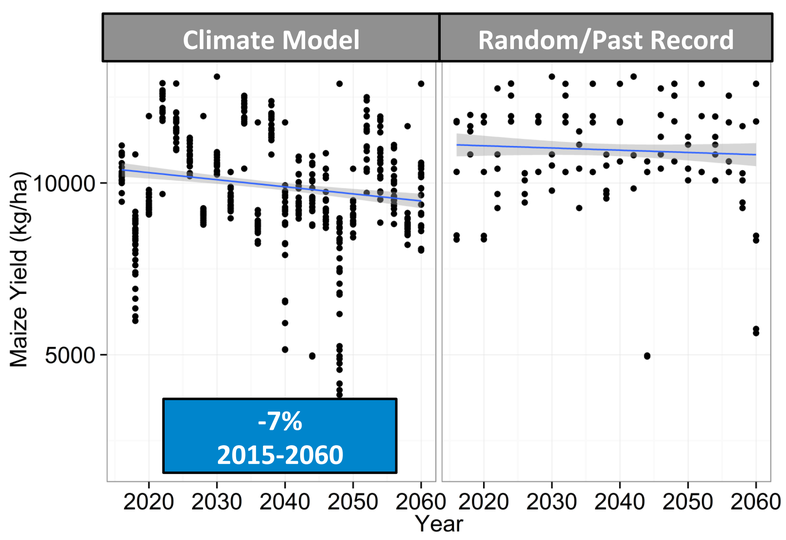
Methods

- Model testing was performed using APSIM – a cropping systems model - with data from a long-term research site in Central Iowa where a cereal rye cover crop was grown every winter in a corn-soybean rotation since 1999
- We investigated a comparison of two different weather outcomes: 1. Scenarios generated by global climate models with greenhouse gas forcing RCP 4.5 following the AgMIP methodology; and 2. Scenarios that were randomly generated from past weather.
- This allowed us to evaluate differences between the long-term climate record and future weather.

Results

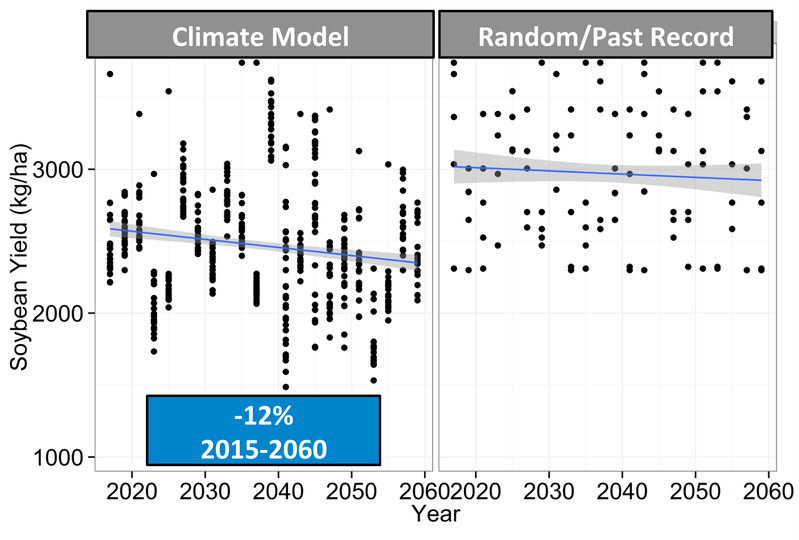
Crop Production Impacts

Corn



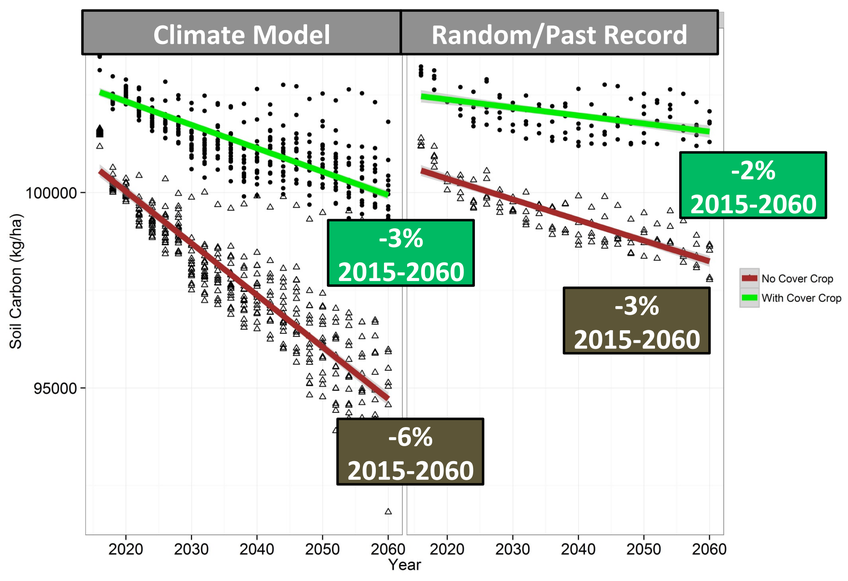
Both corn and soybean yields in the cover crop and no cover crop simulation are predicted to decline through 2060, by 1-2% by decade. Further, the model predicts temperature-driven impacts to corn and soybeans, such as increased water stress and greater soil water demand.

Soybean



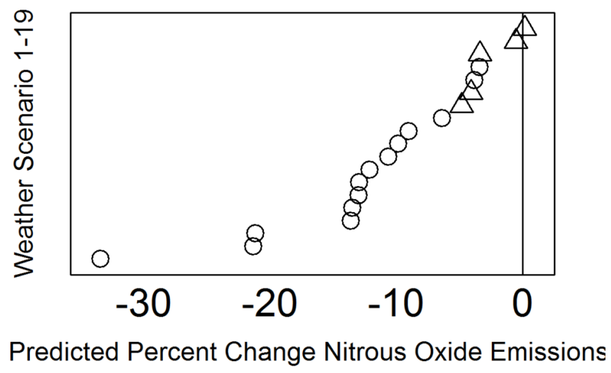
Environmental Benefits

Soil carbon



The cover crop treatment led to 3% higher levels of carbon at the 0-30-cm depth through 2060 in the cover crop simulation. The cover crop biomass year over year reduced soil erosion losses between 11-29% depending on weather scenario.

Nitrous oxide emissions



The cover crop was able to reduce the soil nitrate levels enough to decrease nitrous oxide emissions up to 34% compared to the no cover crop simulation. Declines in emissions were more pronounced in the future weather (circles) compared to long-term trends (triangles) indicating that the cover crop could be an effective mitigation strategy for the Midwest in a warmer climate.

Recommendations

- Farmers sometimes report short term (i.e. one growing season) impacts to corn and soybean yields following a winter rye cover crop. This research indicates that with proper management, the long-term use of a winter rye cover crop does not lead to yield declines in corn-soybean rotations. Climate change, however, drives yield declines in both crops of 1-2% by decade.
- Future climate change drives carbon loss in both the cover crop and no cover crop simulations. While the cover crop shows promise for improving environmental quality - reducing soil erosion by 11-29%, offsetting carbon loss by 3% and decreasing nitrous oxide loss up to 34% - it is not able to negate yield declines. Future research should address a combination of practices to reduce multiple climate change impacts.

A winter rye cover crop in Ames, Iowa, protects the soil following the drought of 2012 and ahead of heavy rains in spring 2013, illustrating the weather-buffering benefits a cover crop can provide compared to a bare field.

Fall sampling of cereal rye cover crop biomass in standing soybeans

Aboveground biomass sampling of corn

IOWA STATE UNIVERSITY
Department of Agronomy

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