EPIC Simulations of Crop Yields and Soil Organic Carbon in Iowa

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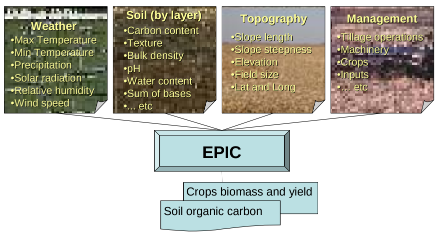
Depending on management, soil organic carbon is source or sink of atmospheric carbon dioxide. The Environmental Policy Integrated Climate (EPIC) model is a useful tool for predicting impacts of soil management on crop yields and soil organic carbon. We are using the EPIC model to study long-term impacts of soil and crop management practices on crop yields and soil organic carbon (SOC) to a depth of 20 cm, in the US Corn Belt. In this poster we report results from Iowa. The model was initialized in 1970 using the NRCS-SSURGO soils data base and Climatic data from NOAA first order stations. Soil and crop management practices were gathered from state and national databases. Model simulations were conducted at daily time step and at a grid-cell level of 1.6 x 1.6 km (one square mile).

Objectives

1. Assess the impacts of tillage practices on corn and soybean yields
2. Assess current soil organic C stocks in corn-soybean croplands in Iowa.
3. Calculate potential C sequestration with increasing adoption of conservation tillage.
4. Estimate current soil organic C sequestration rates.

Methods

EPIC data requirements and main outputs



Weather data

An interpolated grid of daily weather inputs (1970-2005) were created using data from Iowa and neighboring states. For simulations between 2006-2019 weather data was from 2005-1992.

Management operations

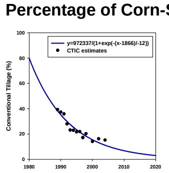
Tillage, planting, harvesting and associated operations for the three simulated scenarios (Conventional, Reduced Till and No Till) were based on NRCS-Rusle2 records.

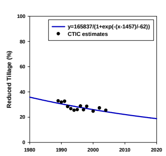
Fertilization practices were obtained from the USDA-Economic Research Service. The dataset shows constant application rates for P and K but increasing trend in N application for corn, which reach a maximum in 1982.

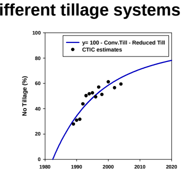
Extent of tillage practices were obtained from the Conservation Technology Information Center (CTIC).

For future simulations (2007-2019) we assumed constant fertilizer application rates and no change in varieties.

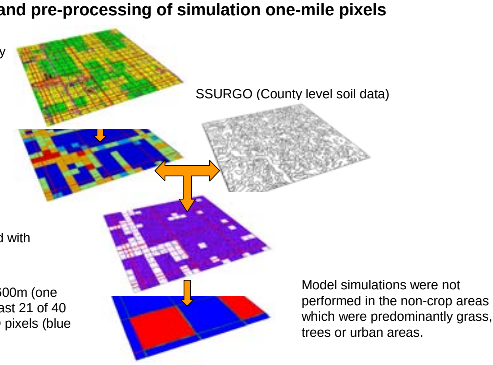
Percentage of Corn-Soybean area in Iowa under different tillage systems







Soil data and pre-processing of simulation one-mile pixels



Web Interface for EPIC

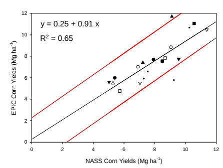
Simulations were run on approximately 30,000 one square mile pixels. A web interface was developed to handle inputs and outputs.

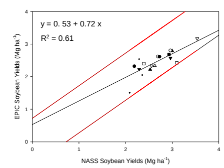
Results

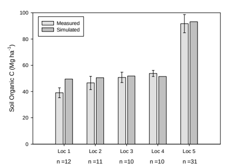
Model Validation

The validation process focused on the crop yields and soil organic C using crop yield estimations from NASS and measured SOC.

In figures on the right, different symbols correspond to different years. Red lines are ± 20% of the 1:1 line.







The figure on the left compares field data (Cynthia Cambardella and Jerry Ritchie, pers. comm.) from Boone and Story Counties versus simulated SOC.

Loc 1 – 4: year 1995, 15 cm depth

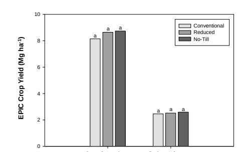
Loc 5: year 2004, 30 cm depth

Standard error bars are shown, n = number of measured SOC for calculating the mean.

Model Estimations

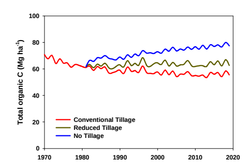
Effects of Tillage Practices on Corn and Soybean Yields

Average (1982-2006) Corn and Soybean yields affected by tillage practices followed the order No-Till > Reduced Till > Conventional Till. However, differences were not statistically significant ($p < 0.05$).

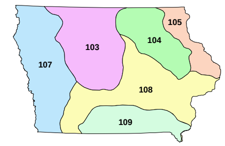


Effects of Tillage Practices on Soil Organic C (top 20 cm)

The Conventional tillage scenario predicts decreases in soil C (emissions to the atmosphere). Reduced tillage would maintain soil C levels. No tillage would restore higher soil C levels; hence, sequester atmospheric C and mitigate greenhouse gas effect.



Simulated Changes in Soil Organic C During the Period 1980-2019

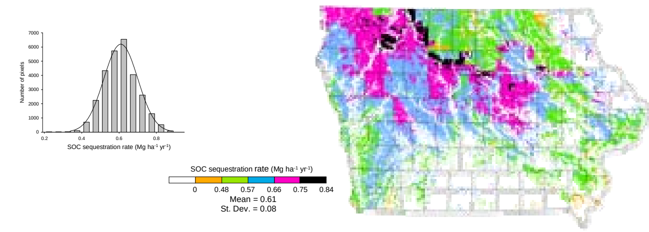


Climate, physiography, soil, and tillage practices affects the magnitude of change in SOC.

Highest negative impact of conventional tillage and lowest positive impact of no till was predicted for the Eastern Iowa and Minnesota Till Prairies (#104), while lowest negative impact of conventional tillage and highest positive impact of no till was predicted for the Iowa and Missouri Deep Loess Hills (#108).

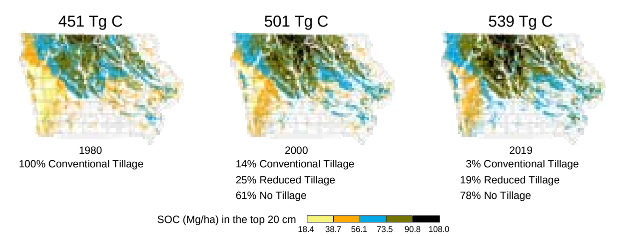
Major Land Resource Area		Tillage System		
		Conventional	Reduced	No Till
		-- Simulated SOC Changes (Mg ha^{-1}) --		
103	Central Iowa and Minnesota Till Prairies	-7.35	-0.79	14.79
104	Eastern Iowa and Minnesota Till Prairies	-8.48	-2.42	11.66
105	Northern Mississippi Valley Loess Hills	-8.49	0.08	14.33
107	Iowa and Missouri Deep Loess Hills	-4.67	3.52	18.35
108	Illinois and Iowa Deep Loess and Drift	-5.74	1.06	15.88
109	Iowa and Missouri Heavy Till Plain	-6.37	0.02	14.37

Carbon Sequestration Rates in 2006



Sequestration rates were calculated as the difference in SOC between conservation tillage and conventional tillage divided by 25 years (conservation tillage adoption began in 1981). Johnson et al. (2002) reviewed SOC sequestration rates in No Till compared to Conventional Till from experiments in IA, IL, IN and OH; the rates were highly variable, an average plus standard deviation of 0.43 ± 0.54 Mg ha^{-1} yr^{-1}).

Temporal Changes in Soil Organic C Stocks



With actual trends in adoption of reduced tillage and no tillage, soil organic C stocks to a depth of 20 cm in corn-soybean croplands would be 539 Tg in 2019; an increase of 88 Tg with respect to SOC stocks in 1980, when all cropland area was conventionally tilled.

Conclusions

The performance of EPIC to simulate crop yields and SOC in Iowa was acceptable. However, more ground data on temporal SOC are needed for better model calibration and validation.

Policies that promote conservation tillage will lead to significant SOC sequestration throughout Iowa, and has the potential for mitigating global warming.

References

Izaurralde, R.C., J.R. Williams, W.B. McGill, N.J. Rosenberg, and M.C.Q Jakas. 2006. Simulating soil C dynamics with EPIC: Model description and testing against long-term data. Ecol. Model. 192:362-384.

Johnson, J.M.F, Reicosky, D.C., Allmaras, R.R., Sauer, T.J., Venterea, R.T., and Dell, C.J. 2005. Greenhouse gas contributions and mitigation potential of agriculture in the central USA. Soil Till. Res. 83, 73-94.