Predicting changes in landscape-scale organic C following the implementation of minimum tillage.

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Abstract

We have assembled an inter disciplinary team to address the issue of how much C may be sequestered in soil of minimum tillage systems in CA agriculture. Our main research goals are to identify and quantify the underlying mechanisms and processes controlling the rate of CO₂ emissions versus soil C stabilization as affected by tillage operations. A landscape research approach is used to increase our mechanistic understanding of the biotic and abiotic processes that govern C dynamics under conventional and minimum tillage practices.

We have selected an irrigated, levelled agricultural site in the CA Central Valley for this study. The 70-acre site, located approximately 10 miles northeast of Davis, has been split into two fields. One field will be managed under conventional tillage and the other under minimum tillage. After harvest of a wheat crop in July, the soil profile has been measured to a 1-m depth in a grid and transect sampling scheme at 140 locations across the two fields in order to establish baseline soil physical and chemical properties including soil C inventory. Each field has been instrumented with: 1) an eddy-covariance mast to measure field-scale CO₂ fluxes; 2) a 0.60-m² chamber with the capability of assessing the temporal pattern of CO₂ and N₂O fluxes; and 3) with 20.113-cm³ chambers in order to evaluate the underlying characteristics of soil C and N₂O fluxes. Some of the gas flux data collected so far is presented here.

Results will be used to modify existing C models to predict the impact of minimum tillage on soil C sequestration. The research will also provide a realistic assessment of the role CA agriculture can play in C sequestration when land is converted from conventional to minimum tillage. Future research will also include a cost-benefit analysis of the two tillage systems.

Background

Terrestrial ecosystems play a critical role in global C cycling. They are considered to be potentially major future sinks of C, and could partially offset the increases in atmospheric CO₂ seen in the last century. As most agricultural soils under conservation tillage practices have the capacity to sequester additional C, these soils have the potential to contribute to the mitigation of global climate change.

Estimations of the net amount of C that can be sequestered by U.S. cropland range from 0.57–1.7 Pg C yr⁻¹. Tillage has a major impact on soil C storage. It has been estimated that the concentration of C in the Great Plains of North America decreased between 28% and 59% following 30 to 45 years of cropping history, respectively. Zero or minimum tillage most often does not directly change C inputs, but improves soil structure and increases aggregate stability, resulting in more protection of SOM (soil organic matter) from microbial degradation. The C that is consequently stored below ground is more permanent than C stored above ground in plant biomass.

Spatial variability in yield, and subsequent SOM input to the soil, vary considerably across the landscape. Different amounts of plant residue input in combination with different bio-physical properties of the soil that control the rate of decomposition appear as distinct spatial patterns across a field. However, the presence of a strong spatial pattern of a bio-physical property becomes a powerful tool in landscape-scale studies.

Data on the capacity of U.S. agricultural soils to sequester C has been varied in conclusion and based largely on experiments in the Midwest. Unique conditions of irrigated agriculture in the hot, semi-arid environment of CA’s Central Valley warrant research directed specifically at modeling the potential for C sequestration in these intensively-managed and productive systems.

Objectives

- To identify underlying mechanisms that control the quantity of C input from below and aboveground components across a typical CA agricultural landscape.
- To determine and quantify the processes that control the rate of CO₂ evolution as affected by minimum versus conventional tillage.
- To improve and validate existing C models in predicting soil C across farmers’ fields following the implementation of minimum tillage.