Predicting Soil C Storage in the Central Valley Following Implementation of Minimum Tillage (seed project)

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Objectives

The overall objective of this one-year, seed project was to investigate the spatial characteristics of a potential field site in order to prepare a full proposal for submission in September 2002. The goals of the preliminary study were to determine the spatial variability of soil organic C at a landscape scale on a farmer's field and assess if clay content was correlated significantly with soil organic C. An additional objective was to determine whether salinity occurred and if it would impact crop growth, therefore, C input into soil.

Introduction

The research team collected preliminary data at a large farm near Winters, managed by Mr. Tony Turkovich. The farm has been used by University of California, Davis, researchers for many years to study precision farming management practices, plant pathological questions related to tomatoes, and the impact of minimum tillage on yield and nutrient cycling, among other research topics. Mr. Turkovich follows minimum tillage practices, and agreed to collaborate on the impact of minimum tillage on C storage across large fields. He maintained records of production costs and income so that a cost-benefit analysis could be done later. The proximity of the research site to UC Davis has several benefits. Foremost, there was an excellent collaboration between Mr. Turkovich and researchers at UC Davis on a number of research projects. Secondly, its proximity to UC Davis made it easier to install equipment and collect data. Some of the proposed data collection was labor intensive and required frequent visits to the site. Finally, the team planned to use the research site for teaching purposes, allowing students to visit the site and learn how landscape studies in agro-ecosystems can be conducted.

Results and Discussion

Total C input in the soil is controlled by the specific growing conditions of the crop that can vary widely at the small scale. When the grain yield of irrigated maize was determined in a small basin (729 m^2) with a Mediterranean climate, the yield varied between 0.3 and 1.15 g m^{-2} (Cavero et al. 2001). Similarly, when the residue yield of pea and wheat was determined in an undulating landscape, a significantly higher residue yield was found in the higher water catchment areas compared to the drier areas (Stevenson and Van Kessel 1996). Such a large spatial variability in yield across the landscape is related to the spatial variability of soil fertility (Or and Hanks 1992), soil organic matter (SOM) content (Pennock et al. 1994), water availability (Letey et al. 1984), and the occurrence of pests (Stevenson and Van Kessel 1996;

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Plant et al. 1999). Similarly, root distribution was affected by the variable growing conditions across a field (Van Rees et al. 1994).

Different amounts of plant residue input in combination with different bio-physical properties in the soil control the rate of decomposition and appear as distinct spatial patterns in total soil C content across a field (Van Kessel et al. 1994). However, rather than eliminate the spatial variability of those processes, the presence of a strong spatial pattern of a bio-physical property becomes a powerful tool in landscape studies. By determining the range by which those bio-physical properties vary across the landscape, their significance in sequestering new C becomes known. Using simulation models, predictions on the impact of various bio-physical properties on C sequestration across the landscape can be made and extrapolated to larger areas.

Because landscape scale variations in soil organic C pools and fluxes can be large, they must be taken into consideration when realistic budgets of total soil C are made. The spatial and temporal variations in soil C can be controlled by soil texture and associated soil moisture regimes. Therefore the experimental layout should be carried out carefully to ensure that differences in soil C are caused by the implementation of the main experimental variable, i.e., tillage practice. Hence, the inherent landscape variability in soil C must be known prior to conducting a study on the impact of tillage on soil C across the landscape.

In 2002, two sites at the Turkovich Farm were selected for preliminary data collection. The first site (60 acres) was in tomatoes. The second study site was composed of two fields of 40 acres each, located adjacent to each other and under alfalfa production. Both sites are in the Sacramento Valley, a few miles west of Davis and have been land planed for irrigation with a slope of about 1%.

For both study sites, soil samples at 24 locations with equal spacing between sampling points were collected and analyzed for organic C and N, particle size, EC and CEC (*table 1*). The average soil C values of both study sites were similar, with values ranging between 0.72 and 0.93percent. With a bulk density of 1.5 g cm^{-3} and a soil depth of 15 cm, the difference in soil C between the highest and the lowest value for percentage of C in the soil is equal to 0.5 kg C m^{-2} or 5 ton of C ha^{-1}. Although the clay content varied between 23 and 46% across the two sites, it was a poor predictor of soil C content. However, relatively good correlations were obtained between percentage of sand and percentage of C and water content. Clearly, other measurements are needed to determine what controls soil C content, i.e., parameters controlling C input versus decomposition, across this field.

As high salinity levels have a major impact on crop growth and hence soil C input, an intense sampling protocol at two depths (surface and subsurface) was carried out to determine the presence of salinity. Using a mobile VERIS 3100 (a contact bulk electrical conductivity survey), both alfalfa fields were mapped for bulk electrical conductivity (EC). This measurement would be an indicator of either salinity or water content, or both. Since EC as measured from soil samples indicated rather low and constant EC, the VERIS survey would be mostly an indication of water content, which would be related to soil texture. The VERIS survey appears to show much more variability than the soil samples showed. The surveys for two different depths show similar spatial patterns. There was a spatial EC pattern across the alfalfa fields, but the EC values observed (<2 dS m^{-1}) are considered to be too low to impact crop growth (data not shown). The absence of a salinity gradient across the field is desirable as it will remove one of the factors that control C input and soil C content.

Based on the preliminary data, we conclude that: (i) soil organic C content can vary considerably across a field with minimal differences in elevation, (ii) particle size distribution is a poor indicator of soil organic C at these sites, and (iii) salinity levels should not impact crop growth at these sites. Also, it was clear that the two alfalfa fields had no significant differences in the basic soil characteristics, including total organic C. Based on these results, the two alfalfa fields were selected to compare the effects of minimum tillage and conventional tillage on C dynamics and sequestration. Because of the absence of any tillage operation during the past four years, the organic C level is potentially near its maximum under these management conditions. Thus, the alfalfa fields will be an excellent location to determine the impact of minimum versus conventional tillage on the behavior of soil C in an irrigated system.

***Table 1**. Basic characteristics of the tomato and alfalfa fields.*

	%C		%N		EC dS/m		% sand		% silt		% clay	
	avg	range	avg	range	avg	range	avg	range	avg	range	avg	range
Tomato field	0.83	0.72-0.93	0.11	0.08-0.13	1.87	0.80-6.50	22	14-33	48	45-53	29	23-39
Alfalfa field	0.79	0.72-0.93	0.11	0.08-0.13	1.36	1.20-1.70	14	11-21	46	41-53	39	33-46

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