Evaluating changes in organic C and emission of greenhouse gases in a California agricultural landscape.

A.P. King[1], D.E. Rolston[1], J.W. Hopmans[1], C. Van Kessel[2], J. Six[2], K.T. Paw U[1], R.E. Plant[2], T.C. Hsiao[1], Rosa M. Poch[1], G. Shaver[1], A.J. Ideris[1], J. Lee[2], A. Wolf[2], K.J. Evatt[1], D. Louie[1], J.L. MacIntyre[1], A.A. Matista[1]

Departments of Land, Air and Water Resources[1] and Plant Sciences[2], University of CA, Davis.

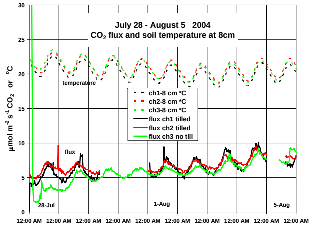
Abstract

A major question in CA agriculture is how much C may be sequestered in soil of irrigated, minimum tillage systems. Our main research goals are to identify and quantify the underlying mechanisms and processes controlling the rate of CO_2 and other greenhouse gas 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 standard and minimum tillage practices.

We have selected an irrigated, laser leveled agricultural site in the CA Central Valley for this study. The 70-acre site, located approximately 10 miles northwest of Davis, has been split into two fields. Beginning in the fall of 2003, one field has been managed under standard tillage (ST) and the other under minimum tillage (MT). Each field is instrumented with 1) an eddy-covariance mast to measure field-scale CO_2 fluxes, 2) with a 0.62-m² automated chamber to assess the temporal pattern of CO_2 and N_2O fluxes, 3) with 27 506-cm² portable PVC chambers to evaluate the spatial characteristics of CO_2, N_2O and NO fluxes, 4) with 4 subsurface soil gas probes to measure CO_2 and N_2O concentrations with depth and 5) with multiple piezometers and tensiometers to monitor the movement of soil water throughout the growing season.

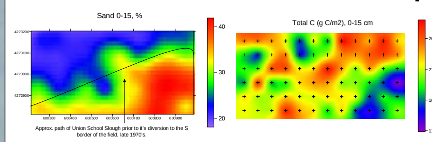
Round-up Ready corn was planted in both fields in April 2004. Preliminary results from this growing season indicate that the various methods of CO_2 measurement compare well with one another. There was no notable difference in soil CO_2 flux between tillage treatments, but the eddy-covariance towers measured differences in net CO_2 flux between treatments based on differential crop growth patterns. The MT treatment had slightly higher N_2O emissions than ST, but N_2O and NO emissions were primarily restricted to areas and time periods of fertilizer application. MT grain yield was 73% of that in the ST treatment. Patterns of soil texture, ground water movement, and treatment effects will continue to be explored to help explain the yield gap and other spatial patterns in the data. Upcoming years of the project also include continued monitoring of greenhouse gases and soil C dynamics in the two tillage systems, comparison of field data with DNDC and Daycent models, and economic evaluation of the two systems. These results will help provide a realistic assessment of the role CA agriculture can play in C sequestration when land is converted from standard to minimum tillage.

Automated CO_2 Chambers

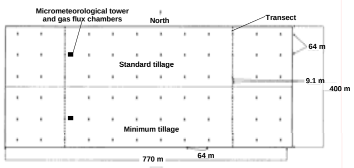


There are 2 chambers in the ST and 1 in the MT fields. They close for 1 minute every half hour, when fans mix the air in the chamber, and measure soil CO_2 flux with an IRGA. They cover a 0.62 m² area, and are used to evaluate **temporal patterns** of CO_2 flux and soil temperature in the fields.

The Field Site and Experimental Design

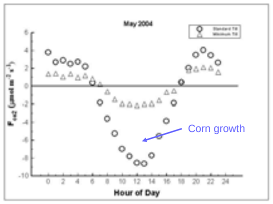


The experiment has sampling plots on a main grid of equidistant points and on 2 dense transects. There is considerable heterogeneity in soil properties such as texture and C, shown above.



Field diagram showing the 140 soil sampling locations. The micromet towers, automated chambers, and below ground sampling locations are located near the west transect in the middle of each field.

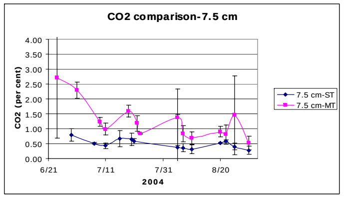
Eddy Covariance Towers



There is a tower in each treatment, along the western transect. The towers measure CO_2 flux, as well as wind speed and direction, radiation from the ground and sky, relative humidity, air temperature, and soil heat flux. The towers provide frequent, field-scale measurements of net gas flux in the fields.

This figure shows data from May 2004; positive values are CO_2 emissions from the soil and crop, and negative values are CO_2 uptake by the crop. Early in this growing season, the corn crop in the MT treatment was significantly smaller, and fixing less CO_2, than in the ST treatment **(see poster by Paw U et. al.)**.

Subsurface soil probes for CO_2 and N_2O

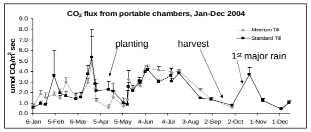


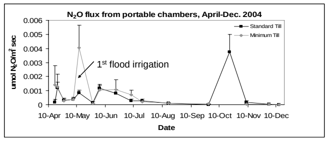
The probes are located along the W transect, where both the towers and auto-chambers are located. They are inserted 1m into the soil and measurements of CO_2, N_2O and temperature are taken at 7.5, 22.5, 45, 75, and 105 cm. There are tensiometers at equivalent depths next to the gas probes to monitor soil moisture with depth. This figure shows higher CO_2 concentrations in MT than ST fields at 7.5 cm depth in the soil, likely due to decreased diffusion of soil gas to the surface in the more compacted MT soil.

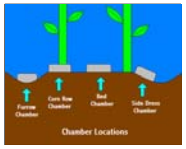
Objectives

- To identify underlying mechanisms that control the quantity of C input from below and aboveground crop components across a typical CA agricultural landscape.
- To determine and quantify the processes that control the rate of CO_2, N_2O and NO evolution as affected by minimum versus standard tillage.
- To improve and validate existing C models in predicting soil C across farmers' fields following the implementation of minimum tillage **(see poster by Wolf et. al.)**.
- To evaluate the economic performance of standard and minimum tillage systems in this field.
- To monitor water movement, balance and quality in the standard and minimum tillage systems.

Portable PVC Chambers for CO_2, N_2O and NO

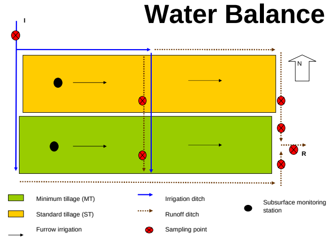






The portable chambers are made of 10" PVC rings permanently installed at locations that span both fields and a portable PVC end-cap lid, which is attached to an IRGA for CO_2 measurement. N_2O is sampled with a syringe from the vented chambers and brought back to the lab for analysis on a gas chromatograph. There are a total of 4 chambers at each sampling location, as shown above. Gas flux data from 2004 indicates little overall difference between tillage treatments, but is being analyzed to evaluate **spatial patterns** of greenhouse gas flux across the fields.

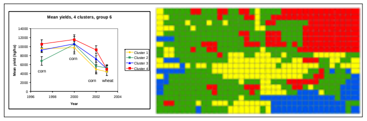
Water Balance and Water Quality



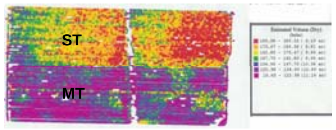
Event			pound per acre				
			C	DON	$N\text{-}NO_3^-$	$N\text{-}NH_4^+$	Total N
6	water	Irrigation	11.1	6.1	3.1	0.1	9.2
		Runoff	8.5	2.8	1.7	0.0	4.5
		Drainage	0.2				0.0
		I-D-R	**2.4**	**3.3**	**1.3**	**0.1**	**4.7**
	sediment	Irrigation	9.0				0.9
		Runoff	2.3				0.3
		I-R	**6.7**				**0.6**
	Total		**9.1**	**3.3**	**1.3**	**0.1**	**5.3**
7		Irrigation	7.1	0.6	0.7	0.0	1.3
		Runoff	3.1	0.3	0.3	0.0	0.5
		Drainage	0.3				0.0
		I-D-R	**3.7**	**0.3**	**0.4**	**0.0**	**0.7**
	sediment	Irrigation	6.7				0.9
		Runoff	0.4				0.1
		I-R	**6.3**				**0.8**
	Total		**10.0**	**0.3**	**0.4**	**0.0**	**1.6**
6 and 7			**19.1**				**6.9**

The last two irrigation events (#6 and #7) of 2004 were analyzed for efficiency and concentrations of C, N, sediment load, and other parameters. Runoff from the fields was considerably lower in sediment than the irrigation water applied. This table shows what the field was taking up in the sediment. For these 2 irrigations, both fields absorbed C and N. There was no difference between tillage treatments in the water measurements **(see poster by Hopmans et. al.)**.

Yield Patterns and Spatial Analysis



Cluster analysis of yields 1997-2003, prior to introduction of tillage treatments.



Yield monitor data from 2004 corn.

Reduced yield in the MT field is being analyzed in the context of yield patterns on the fields prior to the experiment. Other analyses are evaluating spatial patterns of greenhouse gas flux and soil properties **(see posters by Shaver et. al. and Lee et. al.)**.

Acknowledgements

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