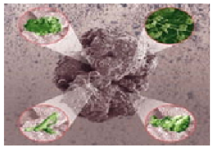
Linking Short-term Aggregate Dynamics, Long-Term C Sequestration, and Fertilizer Quality in Long-Term Cropping Systems

Angela Kong*, Steven Fonte, Francisco Reis, Chris van Kessel, and Johan Six

Department of Plant Sciences, University of California, Davis



Introduction

• Questions regarding long-term agricultural sustainability and concerns about negative environmental impacts from agroecosystems (e.g., increased greenhouse gas emissions, irrigation run-off pollution) must be addressed

• Combined use of organic resources (OR) and synthetic fertilizers (SF) in *low input* crop management systems can be an optimal approach for soil fertility management, C sequestration, improved N cycling, and increased plant productivity

• Understanding how OR and SF influence the mechanistic linkage between soil structural dynamics and nutrient cycling is necessary to developing management strategies that maximize C sequestration

• Many soil processes governing C and N cycling are regulated by aggregate turnover

Abbreviations: CMT, conventional–maize–tomato; cPOM, coarse particulate organic matter; LMT, legume–maize–tomato; mM, microaggregates-within-macroaggregates; OMT, organic–maize–tomato; sc-M, silt-and-clay-within-macroaggregates; SOC, soil organic carbon; SON, soil organic nitrogen; SOM, soil organic matter; WLCC, winter legume cover crop

Objective

• Investigate the relationship between OR and SF additions, whole soil plus aggregate-associated C and N cycling, and N synchrony

•Study site – Center for Integrated Farming Systems site: located in Yolo County, California (Latitude N 38.54, Longitude W 121.87) and characterized as Yolo silt loam and Rincon silty clay loam soil types

Methods

Experimental Design

• Complete randomized design with 3 maize-tomato (MT) cropping system treatments: 1) *conventional* (CMT), 2) *low-input*, (LMT), and 3) *organic* (OMT)

• 3 replicates of each treatment

• $^{13}C/^{15}N$-labeled WLCC applied at 1.1 Mg C·ha^{-1} and 0.10 Mg N·ha^{-1} into the LMT and OMT plots

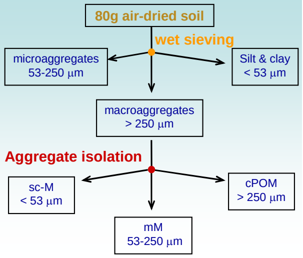
• Split application of ^{15}N-labeled urea at 0.24 Mg N·ha^{-1} to CMT plots

Sampling and Analytical Procedures

• 4 soil sample collection periods (0-15 cm depth): 3-13, 6-17, 8-2, and 9-21-2004

• ^{13}C and ^{15}N isotopic analysis on whole soils, aggregate fractions, maize biomass, and grain

Soil Fractionation Procedure



Results & Discussion

Figure 1. 2004 maize grain yields at the CIFS site in the CMT, LMT, and OMT cropping system treatments.

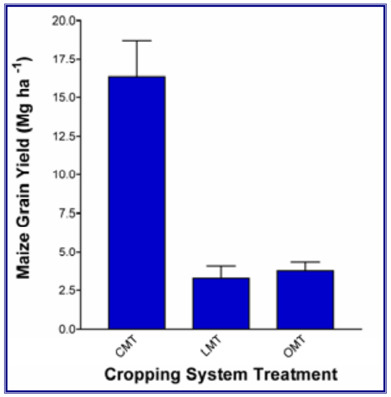


Figure 2. SOC and SON change over 11 years of CMT, LMT, and OMT cropping system management.

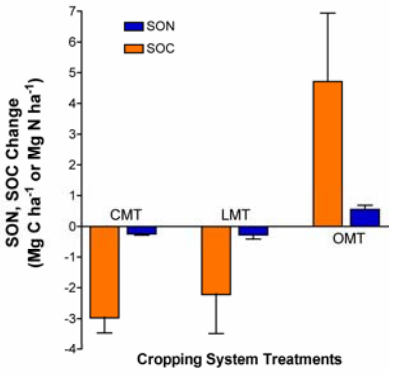


Figure 3. Trends in aggregate-associated N_{new} across the maize growing season.

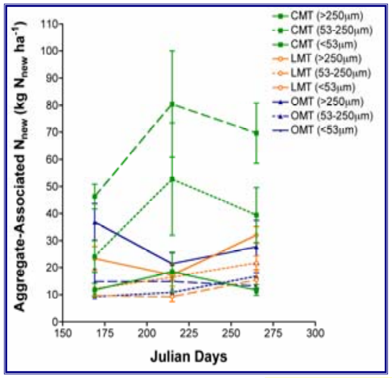
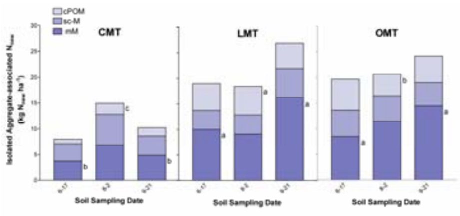


Figure 4. N_{new} of SOM fractions isolated from macroaggregates of the CMT, LMT, and OMT cropping system treatments. SOM fractions followed by '*a, b,* or *c*', within one sampling period, are significantly different ($p < 0.05$).



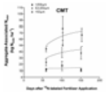


Table 1. Turnover times of aggregate fractions extracted from CMT, LMT, and OMT cropping system treatments, as determined by ^{15}N content.

Cropping System Treatment	Macroaggregate (>250µm)	Microaggregate (53-250µm)	Silt-&-clay (<53µm)	mM (53-250µm within M)
CMT	262	58.9	55.7	42.6
LMT	142.9	277.8	416.7	135.1
OMT	*N/A*	588.2	*N/A*	98

Figure 5. Trends of aggregate-associated C_{new} across the maize growing season. ^{13}C data only available for LMT and OMT cropping system treatments.

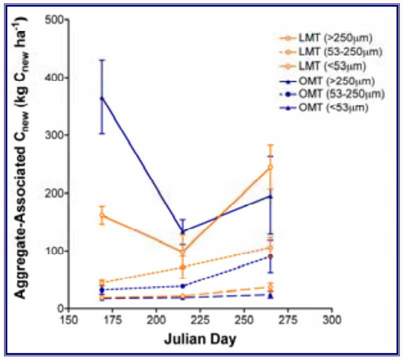
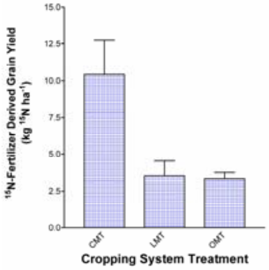


Figure 6. Synthetic fertilizer (CMT) or WLCC-derived (LMT and OMT) ^{15}N in maize grain yields.



Highlights

- **Highest maize yields in CMT, but SOC, SON contents in whole soil and aggregate fractions highest in the OMT system**
- **OMT system sequestered C in long-term (11 years), but CMT and LMT systems *lost* C**
- **Faster turnover times of aggregate-associated ^{15}N were found in CMT system (26-56 days) than the OMT and LMT systems (142-588 days), respectively**
- **Fertilizer-derived grain N was highest in the CMT system ($p < 0.05$)**
- **Lack of difference in the WLCC residue-derived $^{13}C/^{15}N$ in the aggregate fractions and the grain between the OMT and LMT systems did NOT corroborate our hypothesis that the LMT system would exhibit intermediate aggregate turnover, leading to optimal balance between C and N stabilization coupled with greater N synchrony**
- **^{13}C sequestration was not observed in either the aggregates or the whole soil of the OMT system**
- **This data set shows a de-coupling of short-term C dynamics with long-term C sequestration trends**

REFERENCES:
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*Corresponding author (aykong@ucdavis.edu)