49 Years of Tillage Impacts on Soil Aggregates and Aggregate-Associated Carbon and Nitrogen

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Introduction

- Soil carbon (C) sequestration, *accumulation of C in the soil*, is critical to reduce carbon dioxide concentrations in the atmosphere and combat global warming.
- Improving soil aggregation (Fig.1), ***the binding of soil primary particles together with organic matter***, and aggregate stability is important because it (i) decreases soil loss through erosive forces such as wind and rain and (ii) protects soil C from mineralization.

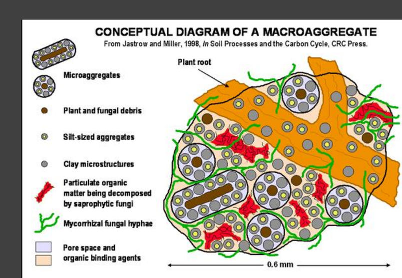

Fig. 1: Diagram of a macroaggregate; Jstrow and Miller (1996).

- Shifting from conventional tillage (soil disturbance) to undisturbed soil [no-till (NT) systems] improves soil aggregation; yet, it is unknown how alternating NT and tillage (a typical practice in Midwest) effects soil aggregation and C sequestration.
- We hypothesize that (i) rotationally tilling soil after two years of NT (alternate tillage) does not result in improved aggregation and C buildup; (ii) NT improves aggregation, C sequestration, soil moisture availability and corn production as a result.

Objectives

Our objective was to evaluate the impact of 49 years of various tillage systems on (i) soil aggregate size distribution and stability; (ii) aggregate associated C, N and permanganate oxidizable C (POXC).

Materials & Methods

Field trial

- A field experiment was initiated in 1970 at Belleville Research Center near Belleville, IL. The soil type is Bethalto silt loam.
- The experimental design was a randomized complete block design with four replications.
- Tillage treatments were [moldboard plow (CT), alternate tillage of 2-yr no-till followed by 1-yr moldboard plow (AT), chisel plow (RT), and NT].

Data collection and analysis

- In spring 2018, soil samples were collected from each plot (0-15 cm depth), air dried, and sieved to 4.75 mm prior to aggregate size distribution analysis. An automated shaker was used to separate the aggregates into different sizes as shown in (Fig. 2a).
- Aggregate sizes were then separated into large (2-4.75 mm) and small (0.25-2 mm) aggregate sizes for wet aggregate stability test (Fig. 2b).

Materials & Methods (Cont.)

Data collection and analysis (cont.)

- Soils from large and small aggregates were pulverized, prepared, and analyzed for total organic C and nitrogen (N) (Fig. 2c) as well as POXC (active C).
- Soil temperature and moisture were measured in the top soil (0-12 cm) for NT and RT periodically during the growing season.
- Data were analyzed using the MIXED procedure in SAS 9.4 using Kenward–Roger's degree of freedom option.

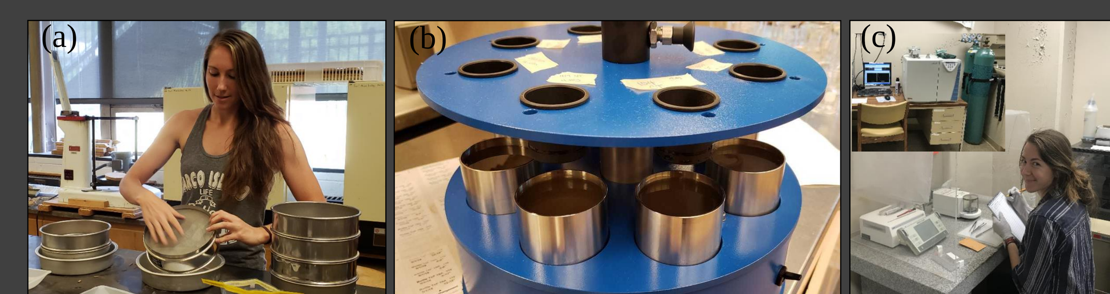

Fig. 2: Testing for aggregate size distribution (a), wet aggregate stability (b), and aggregate associated C and N (c).

Results

Aggregate size distribution and stability

- Results showed a lower percentage of small aggregates in NT than other treatments including both CT and AT (33%) (Fig. 3). These results indicate AT did not contribute to increasing soil aggregation (Fig. 3) compared with CT.

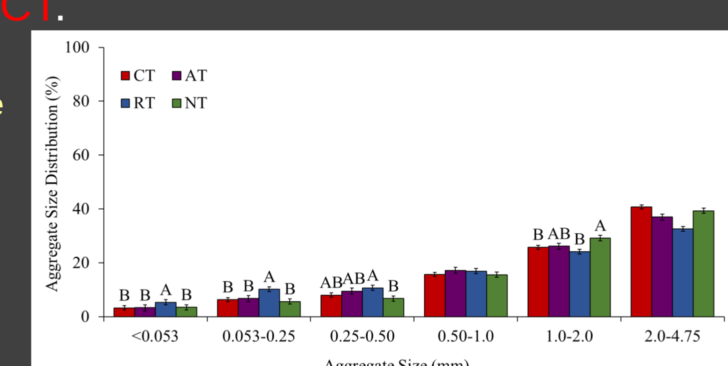

Fig. 3: Soil aggregate size distribution as influenced by tillage systems.

- A higher percentage of small stable aggregates was recorded in NT (64%) followed by RT (55%), AT (52%), and CT (43%) (Fig. 4a) indicating AT increased aggregate stability compared to CT.
- Percentage of large stable aggregates followed the same trend as small aggregates but data were marginally significant (*P*<0.06) (Fig. 4b). These results indicate that larger aggregate size recorded in CT did not translate into greater stability and thus, could be subject to erosion loss and/or cause slaking (low infiltration) in heavy rainfall events.

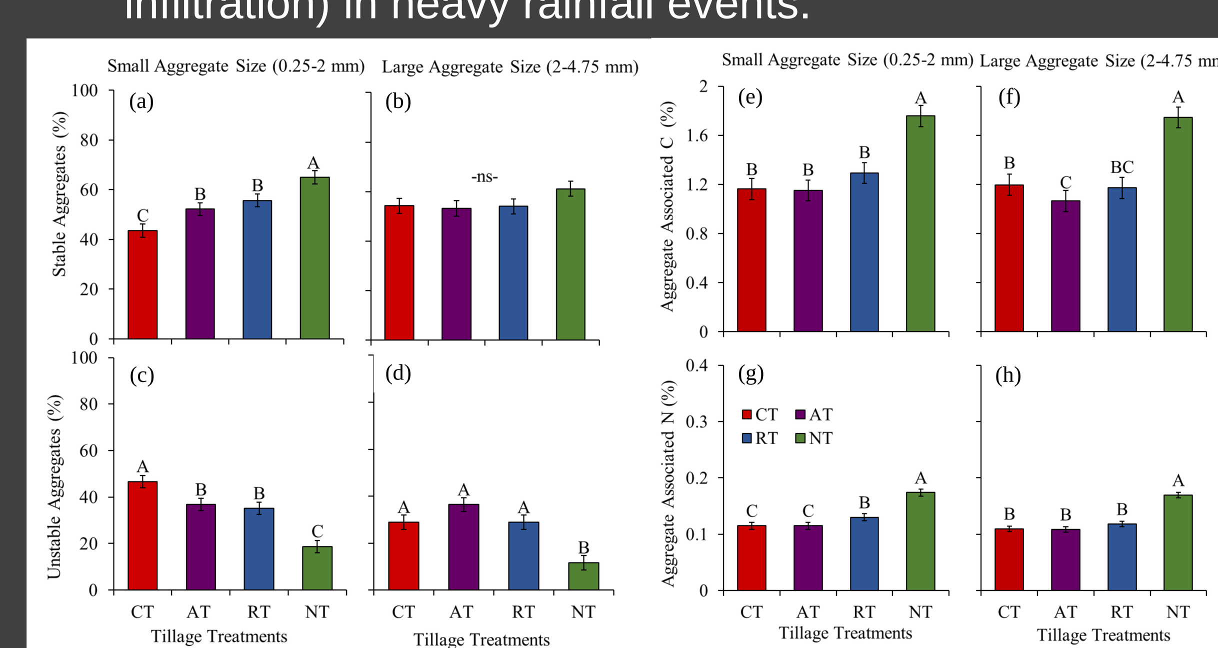

Fig. 4: Small and large, stable (a-b) and unstable (c-d) aggregate sizes and aggregate associated C (e-f) and N (g-h) as influenced by tillage systems.

Results (Cont.)

Aggregate associated C and N

- Soil C and N in NT management was higher in both large (2-4.75 mm) and small (0.25-2 mm) aggregate sizes than other tillage treatments (Fig. 4e-h).
- Except for higher C in CT than AT in large aggregate sizes (Fig. 4f), there were no differences between the two tillage's indicating AT has more stable aggregates but a lower capacity for C accumulation due to lower yields.

Aggregate associated POXC

- Soil POXC in NT was higher in all aggregate sizes except for micro (0.053-0.25 mm) size with no differences between CT and AT (Fig. 5).

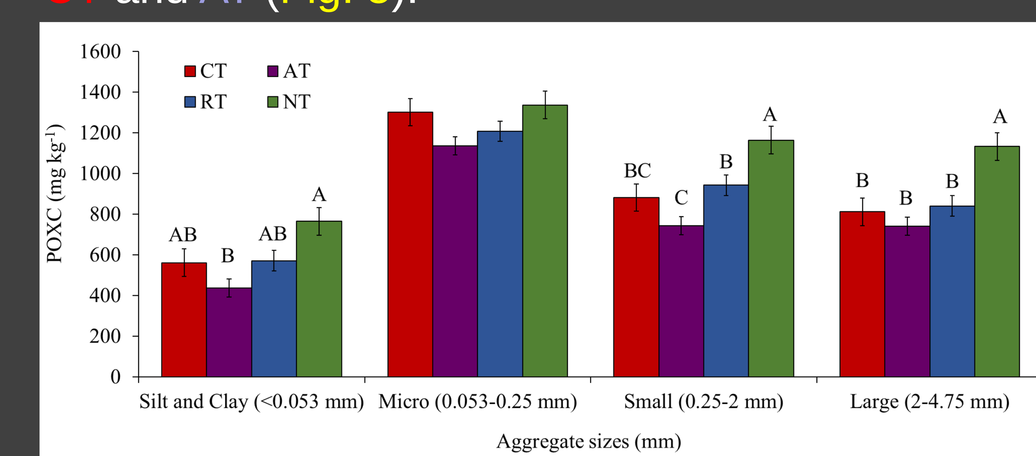

Fig. 5: Soil aggregate size distribution as influenced by tillage systems.

- NT had greater POXC in both stable and unstable aggregates (Fig. 6a-d) compared to other treatments indicating potentially that ***mismanagement of a long-term NT system*** could result in greater loss of active C compared with other tillage systems.

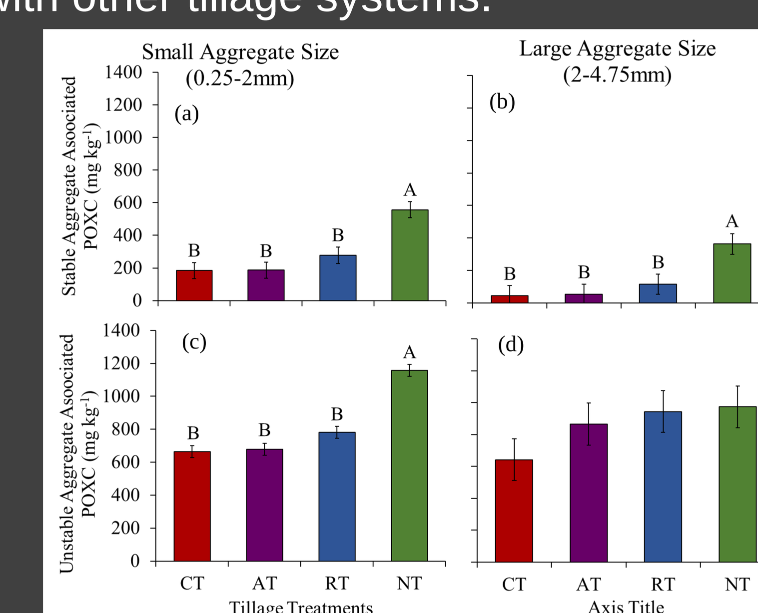

Fig. 6a, 6b, 6c, 6d: Tillage effect on water stable small (a) and large (b) aggregate associated POXC (mg kg⁻¹) in addition to water unstable small (c) and large (d) aggregate associated POXC (mg kg⁻¹) after applied for 49 years

Conclusions/Implications for Agriculture

- Alternate tillage does improve small aggregate stability compared to conventional tillage alone.
- NT improves aggregation and aggregates are less prone to breakdown in heavy rainfall events
- Soil C improves aggregate stability
- Mismanagement of a long-term NT system results in a greater loss of POXC.

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