不耕起栽培による団粒構造の発達が土壌有機炭素の安定性及び土壌の保水性にもたらす影響

Enhancing soil aggregation improves soil organic carbon stabilization and water retention under a long-term organic no-tillage system

Rahmatullah HASHIMI [1]・Atsushi SAKAGUCHI [2]・Masakazu KOMATSUZAKI [2*]

[1] United Graduate School of Agricultural Science, Tokyo University of Agriculture and Technology・[2] College of Agriculture, Ibaraki University

要旨(Abstract)：Organic no-tillage enhances plant residue retention on the soil surface and increases the amount of soil organic matter (SOM). This SOM's active components help create larger soil aggregates, which in turn stabilize soil organic carbon. This combination of organic carbon and macroaggregates enhances both water infiltration and retention in the soil.

キーワード：土壌団粒，保水性，土壌有機炭素

Keywords: Soil aggregates, soil water retention, soil organic carbon

1. Introduction

Soil organic carbon (SOC), soil aggregation, and soil hydraulic properties are important soil quality indicators and may differ among different tillage systems. However, the response of soil SOC, soil aggregation, and soil water retention (SWR) to long-term organic no-tillage (NT) has not been well addressed in Andosol soil.

Therefore, the objectives of this study were to evaluate the effect of NT and organic conventional tillage (CT) tillage systems on SOC, water-stable aggregates, SOC accumulation in various aggregate size fractions, and SWR.

2. Material and Methods

This experimental site is at the Center for International Field Agriculture Research and Education, Ibaraki University, Japan. The experiment was performed as a split-plot design with four replications that consisted of two tillage systems (NT and CT). The CT treatment plot involved two rounds of tillage operations each year using rotary tillage to 15 cm soil depth. In August 2022, we took soil samples (0–5, 5–10, 10–15, and 15–20 cm) to measure total C and N, water-stable aggregates, and bulk density. Additional soil samples (8.5 cm) with diameters were used to measure the soil water retention curve (SWRC) by Hyprop 2.

3. Result

At 0–5 cm depth, SOC was significantly higher in NT in all aggregate size fractions than in CT (Fig. 1). NT had no significant effect on SOC at 5–10, 10–15, and 15–20 cm depths.

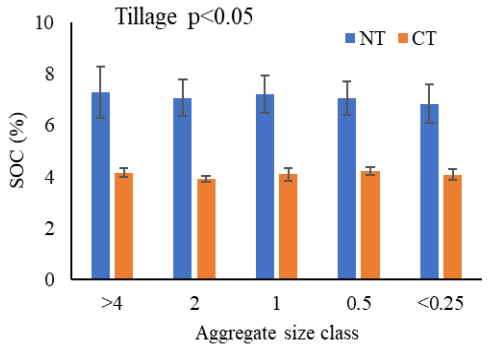

Fig.1: NT effect on SOC content

Aggregate-associated SOC stock was influenced by tillage and aggregate size fraction (Fig. 2). In NT, at 0–5 cm soil depth, SOC was mainly stored in >4 mm

aggregates, followed by 2 mm aggregates which were 37.8% and 20.0% respectively.

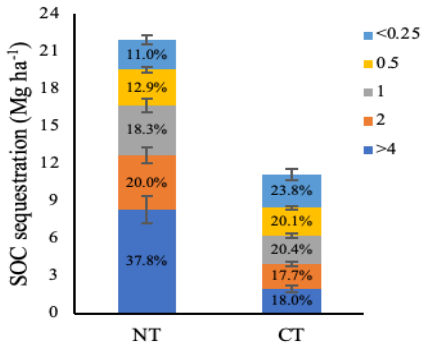

Fig.2: NT effect on SOC accumulation

However, in CT, SOC was stored at 18.0% and 17.7% in >4 mm aggregates and 2 mm aggregates respectively. 21.4% and 16.3% respectively.

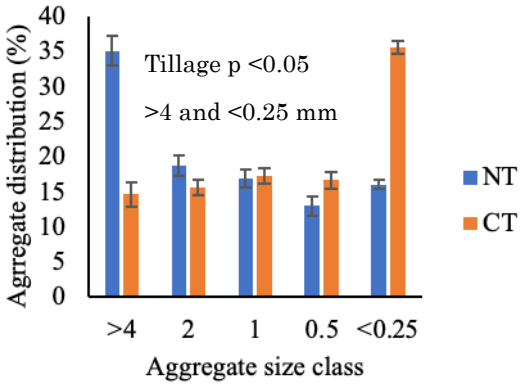

Fig.3: NT effect on water-stable aggregates size distribution

The proportion of >4 mm aggregates was significantly higher in NT treatment than in CT, while the <0.25 mm aggregates fraction was higher in CT than in NT (Fig. 3).

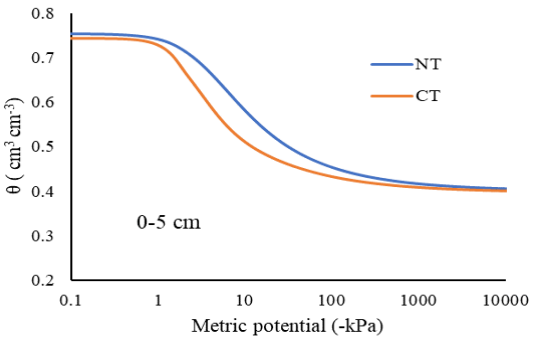

Fig.4: NT effect on soil water retention

NT had 0.62 volumetric water content θ (cm^3 cm^{-3}) at the field capacity level (6.2 kPa) than CT which had 0.54 θ (cm^3 cm^{-3}). The total plant available water content at (6.2 kPa–1550 kPa) was 7.1% higher in NT compared to CT at 0-5 cm soil depth (Fig. 4).

4. Discussion

Organic NT with weed cover mulch improves macroaggregate formation and enhances SOC stabilization, especially within macroaggregates, improving soil water retention. Long-term NT with Rye cover crop combination enhanced 0.49 θ (cm^3 cm^{-3}) at the field capacity level (Hashimi et al., 2023). However, in this study, organic NT with a weed-cover mulch system enhanced 0.62 θ (cm^3 cm^{-3}) which increased by 13% as compared to the previous study. Therefore, extra weed mulch in organic NT could be a good alternative as a cover crop and can effectively utilize soil water reservoirs to improve crop yields in drought-prone conditions.

5. Conclusion

Organic NT farming practices have a positive impact on soil carbon storage, improve soil structure stability, and enhance soil water retention, as the undisturbed soil structure promotes improved infiltration and reduces evaporation leading to more resilient and sustainable agricultural management.

6. Reference:

Hashimi, R., Huang, Q., Dewi, R.K., Nishiwaki, J. and Komatsuzaki, M., 2023. No-tillage and rye cover crop systems improve soil water retention by increasing soil organic carbon in Andosols under humid subtropical climate. Soil and Tillage Research, 234, p.105861.https://doi.org/10.1016/j.still.2023.105861