Effect of Residue Application Methods and Long-Term No-Tillage Management on Residue Decomposition and Priming Effect in Japanese Andosol: Evidence from a Field Incubation Experiment

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Introduction

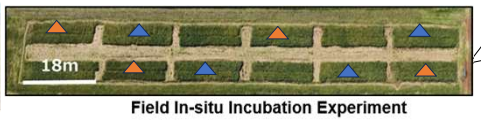
- No-tillage (NT) is an important soil management practice – with proven potential for improving SOC stocks in Andosols as observed from long-term experimental trials within humid subtropical climate of Japan.
- However, NT has been associated with increased CO_2 emissions in Andosols raising questions about its mechanisms and effectiveness for C sequestration.

The study aimed to assess how residue application method and long-term NT management affect residue mineralization, SOC dynamics and priming effect through in-situ incubation experiment using ^{13}C-labelled plant residues in Japan

Conclusion

- Residue application method, not long-term NT legacy, influenced residue mineralization.
- CTSA (surface application/ disturbance) increased mineralization and P.E., likely due to a larger positive relative MBC changes.
- CTMIX (residue mixing) reduced mineralization, possibly due to enhanced residue mineral adsorption after reaggregation.
- Long-term NT likely contributed to stable MBC following surface residue application, leading to reduced SOC priming response → **potential for C stabilization**.

Materials and Methods



Field In-situ Incubation Experiment

Centre for International Field Research, Ibaraki University, Japan est. 2002, Soyabean x Cover crop rotations

Undisturbed soil sampling involved carefully extracting intact soil cores from no-till systems to preserve natural soil structure and composition.

Plant Residue (^{13}C- labelled)

Size - <5mm
Crop – Rye grass

C/N = 25
^{13}C = 7 atm%
Applied rate = 2 kg C m^{-2}

3 Tillage treatments: NT SA, CT Mix, CT SA

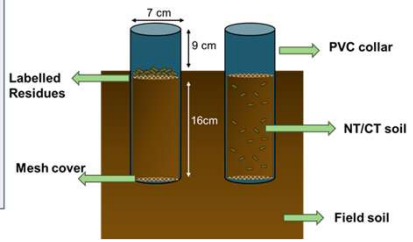
Residue type: Leaf part ^{13}C ^{15}N Rye grass × 4 reps

Two control groups → NT and CT without residues

to compare effect of soil structure changes in relation to soil disturbance and residue application

Field Incubation set up

Surfaced applied | Mixed



Measurement and Calculations

- CO_2 measurement
  - daily, weekly, bi-monthly

$$f_c = \frac{atm\%^{13}C_{treatment} - atm\%^{13}C_{control}}{atm\%^{13}C_{residue} - atm\%^{13}C_{control}} \quad (1)$$

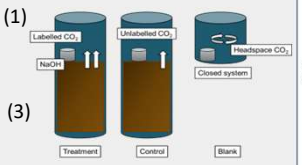
$$C_{residue} = Total\ C_{respired} \times f_c \quad (2)$$

$$Priming\ effect\ (P.E) = CO_2\text{-}C_{soil} - CO_2\text{-}C_{control} \quad (3)$$

- Microbial biomass carbon
  - Days 28, 91, 183

Two-pool mineralization kinetic model

$$C_{(t)} = C_0 (1 - e^{-k_1 t}) + C_1 (1 - e^{-k_2 t}) \quad (4)$$



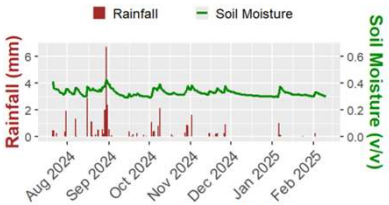
CO_2 measurement

Physical and Chemical Properties of Long-term NT and CT soil

Tillage	Depth (cm)	pH	Total C	Total N	C/N	Avail P	MBC	Bulk density
			-------g kg^{-1}-----			mg kg^{-1}	mg g^{-1}	g cm^{-3}
NT	0-5	6.2	64.6 b	6.2 b	10.3	21.8 b	1.11b	0.72
	5-15	6.3	38.5 a	3.8 a	9.9	9.1 a	0.38a	0.78
CT	0-5	6.4	45.1 a	4.4 a	10.2	13.3 ab	0.49a	0.78
	5-15	6.3	40.6 a	4.1 a	9.7	15.0 ab	0.34a	0.83

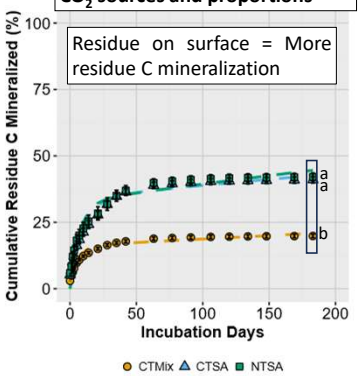
Data are means (n=4)
Different letters indicate significant differences between the treatment-depth combinations based on Tukey's HSD test (α = 0.05)

Environmental Conditions

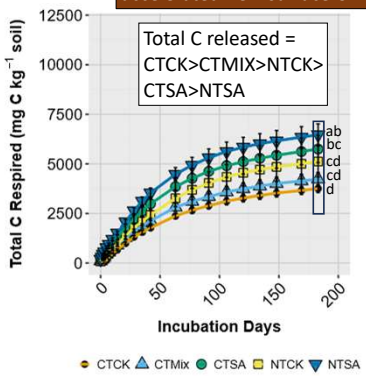


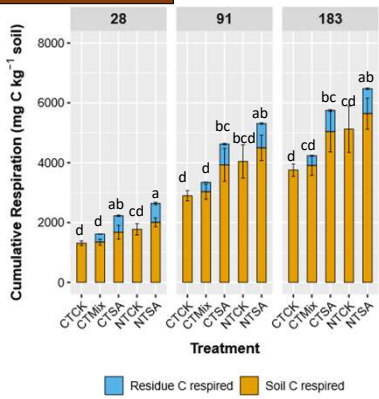
Results and Discussion

CO_2 sources and proportions



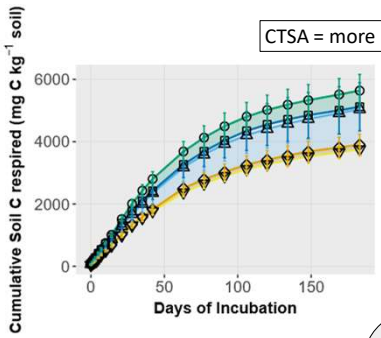
More CO_2 from NT system associated with accelerated new surface C input mineralization

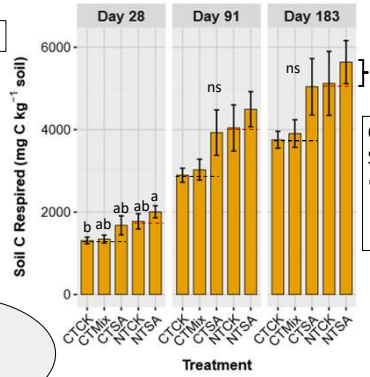




Priming of SOC mineralization

CTSA = more priming



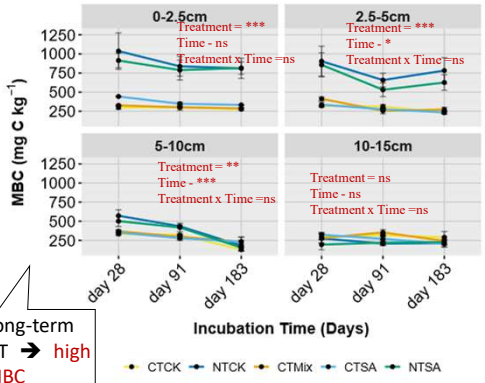


CTMIX = reduced SOC priming
→ **applied Carbon diluted = less MBC response**

Priming lower in NTSA than CTSA

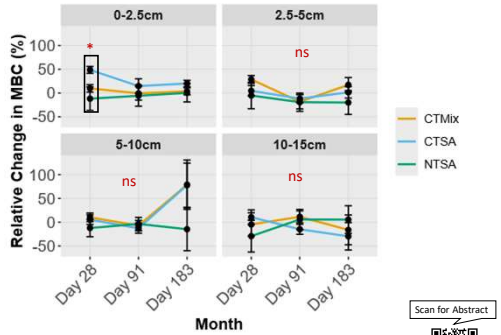
Long-term NT management matters!

Microbial Biomass Carbon Dynamics



Long-term NT → high MBC

Shift in MBC response (CTSA) → potentially enhance SOC priming



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