Stabilization of soil organic matter by reactive aluminum phases in agricultural fields under volcanic influence

Increasing soil organic matter (SOM) storage in agricultural soils is needed to mitigate climate change and improve soil fertility. Particularly in humid tropical regions, high temperatures and high soil moisture can reduce SOM content. Understanding the factors that control SOM storage is a key step towards effective soil management for sustainable crop production. While clay + silt content is known to be an important factor in the stabilization of soil organic carbon (SOC)*, recent studies have shown that oxalate-extracted Al (reactive Al) is of greater importance. Reactive Al roughly corresponds to organo-Al complexes and amorphous clay**, and is formed through weathering of volcanic debris. However, in the tropics, most studies have been conducted on weathered soils with low reactive Al content, and the relationship between reactive Al and SOC content in different land uses has not been fully understood. This study aimed to clarify the factors regulating SOM content in agricultural fields compared to secondary forests or home gardens in Negros Occidental, Philippines. Sugarcane fields have been continuously cultivated for more than 70 years in the study site (Fig. 1).

SOC showed significant positive correlations with reactive Al content, but not with clay + silt content (Fig. 2). The slope of the regression line between SOC and reactive Al was not significantly different between sugarcane and the other two land uses, while the intercept was significantly lower in sugarcane sites (Fig. 3). These results suggest that land use conversion from forest to sugarcane decreases the SOC fraction (particulate organic matter***) that is relatively easily decomposed by soil microorganisms but does not decrease the SOC fraction stabilized by reactive Al.

Even in humid tropical regions where SOM is easily depleted, it is possible to achieve soil carbon sequestration in agricultural fields by developing technologies to increase the SOC fraction stabilized by reactive Al under volcanic influence. To develop such technologies, it would be necessary to evaluate the effects of factors (e.g., reactive Al content, SOC saturation level, quality and quantity of organic materials applied to fields) on the amount of change in SOC stabilized by reactive Al.

*Stabilization of SOM: resistance to decomposition by soil microorganisms

**Amorphous clay: general term for clay with low crystallinity

***Particulate organic matter: Coarse SOM derived from fallen leaves, dead roots, and dead soil animals

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Fig. 1. Sampling points for each land use type

Sugarcane fields, secondary forests, and home gardens in Negros Occidental, Philippines

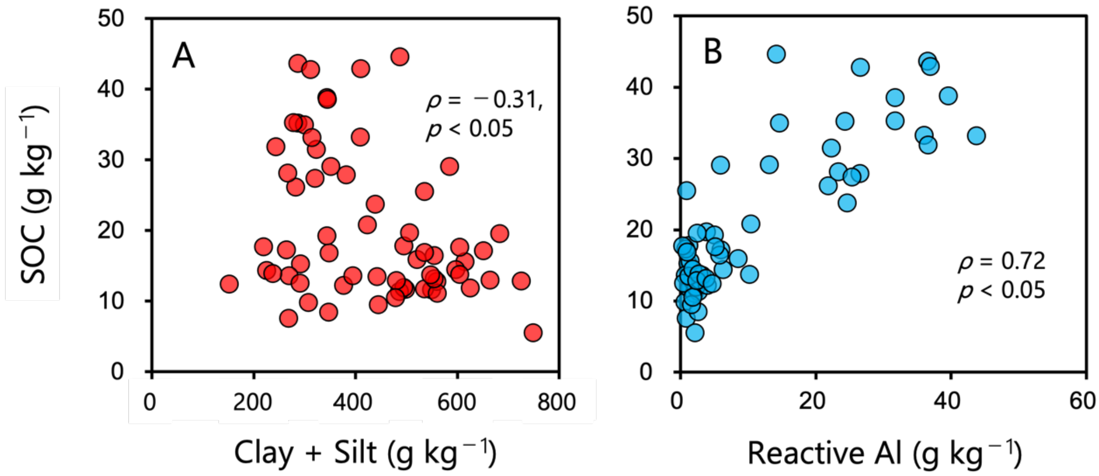

Fig. 2. Relationships between soil organic carbon (SOC) and clay + silt content (A) and reactive Al content (B)

Spearman's rank correlation coefficient (ρ) and *p* value are shown. Soils were collected at 0–10 cm depth from sugarcane fields (n = 33), secondary forests (n = 10), and home gardens (n = 23) in Negros Occidental, Philippines.

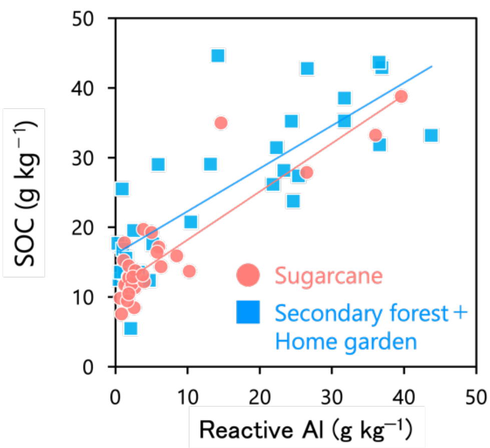

Fig. 3. Relationship between reactive Al content and SOC content by land use

Regression lines are shown for sugarcane fields (red; n = 33; y = 0.69x + 11.27, R^2 = 0.78, $p < 0.05$), which were highly anthropogenically disturbed, and other land uses (secondary forests + home gardens) (blue; n = 33; y = 0.61x + 16.16, R^2 = 0.78, $p < 0.05$), which were less disturbed. Analysis of covariance showed no significant difference in the slopes of the two regression lines ($p > 0.05$), but a significant difference in the intercepts ($p < 0.05$). This indicated that there was no difference in the SOC fraction stabilized by reactive Al between land uses.

Reference: Arai et al. (2025) *Soil Science and Plant Nutrition* 71: 27–37.