学　位　論　文　要　旨

Effect of no-tillage on soil organic matter accumulation characteristics of Andosols in a long–term experiment in Japan

黒ボク土における長期の不耕起栽培が土壌有機物の蓄積特性に与える影響の解明

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Andosols in Japan are predisposed to the loss of huge amounts of soil organic matter (SOM) due to intensive land use and rotary cultivation practices. No-tillage (NT) has been recommended for improving carbon (C) sequestration, sustaining SOM levels, and mitigating climate change, but there is limited information about the effect of NT on SOM accumulation characteristics of Andosols in Japan. The objectives of this study were to evaluate the effect of NT on 1) soil C, nitrogen (N), and phosphorus (P) accumulation characteristics, including its quantity and quality, using physical fractionation methods, and on 2) soil microbial biomass (SMB) and its activity. To achieve the above objectives, in a long–term experimental field at Ibaraki University, the following four studies were conducted using soils from NT and conventional tillage (CT) management of Andosols at each soil depth, i.e., 0–2.5, 2.5–7.5 and 7.5–15 cm.

[1; CHAPTER 3] Several studies have verified the positive effects of NT on the C and N accumulation of Andosols in Japan. However, little is known about the effect of NT on the C and N accumulation characteristics of Andosols. In this chapter, C and N accumulation characteristics of soil were compared between NT and CT using physical fractionation methods (250–2000μm;cPOM, 53–250μm; fPOM, <53μm; mOM). Total C (TC) of cPOM and fPOM in NT at 0–2.5 cm was 7.4 and 10.7 g C kg^{-1}, respectively, and were larger than those in CT (3.8 and 5.5 g C kg^{-1}, respectively). Similarly, TC of both POMs was larger in NT (6.6–8.6 g C kg^{-1}) at 2.5–7.5 cm than in CT (4.4–5.3 g C kg^{-1}). The total C stock of cPOM and fPOM in NT at 0–7.5 cm was 3.4 and 4.6 Mg C ha^{-1}, respectively, and were larger than those in CT (2.1 and 2.7 Mg C ha^{-1}, respectively). However, there was no difference in mOM and deeper depth (7.5–15 cm). Finally, the total C stock at the 0–15 cm depth

did not differ between NT and CT due to the larger total C stock of fPOM and mOM in CT at the 7.5–15 cm depth. TN content and the stock followed a similar accumulation pattern to C. These results indicate that long–term NT management increased the C and N of labile fractions at the surface depths (0–7.5 cm), but not at the deeper depth (7.5–15 cm) and not in stable fraction of Andosols in Japan.

[2; CHAPTER 4] Phosphorus is an essential nutrient for crop production and soil fertility management, as it affects the crop productivity and carbon mineralization and stability process in Andosols. However, there is little information about the effect of NT on P accumulation characteristics of Andosols. In this chapter, P accumulation characteristics were compared between NT and CT using the same physical fractionation methods. NT increased organic P (Po) in cPOM and fPOM by 87.5% and 97.4% at the 0–2.5 cm depth, respectively, and 60.5% and 50.7% at the 2.5–7.5 cm depth, respectively, as compared to CT. However, NT did not affect Po accumulation in mOM throughout the depths (0–15 cm). These results indicate that NT increased the Po in labile fractions at the surface depth (0–7.5cm), causing the better soil P fertility of Andosols in Japan.

[3; CHAPTER 5] Carbon mineralization and stability are tightly coupled with N and P, such as stoichiometry, which is essential for understanding soil nutrient dynamics and SOM quality. However, there is limited information about the effect of NT on SOM quality in each physical fraction of Andosols. In this chapter, the C:N, C:Po, and N:Po ratios were compared between NT and CT for each fraction. There was no clear difference in most fractions between NT and CT, and thus it indicates that NT management did not influence the SOM quality of Andosols in Japan.

[4; CHAPTER 6] Land management such as NT should affect SMB and its activity, possibly reducing SOM loss. Hence, in this chapter, the effect of NT on SMB and its activity were investigated. Microbial biomass carbon (MBC), microbial biomass nitrogen (MBN), and β–glucosidase activity were significantly larger in NT than in CT at the surface depths (0–7.5 cm). These results indicate that NT improves the soil biological conditions and nutrient availability at the surface depth (0–7.5 cm). In conclusion, the long–term NT management in Andosols should (1) increase the SOM accumulation mainly in labile fractions, such as cPOM and fPOM, at the surface depths (0–7.5 cm), with increasing SMB and its activity, and (2) be a sustainable SOM management practice to improve SOM levels and soil fertility, resulting in the sustainable management of Andosols in Japan.