Factors Affecting Organic Carbon Accumulation in Humus Horizons of Andosols from the Tohoku University World Andosol Database

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Introduction Andosols or Andisols accumulate large amounts of soil organic matter (SOM). It is generally considered that SOM stabilization is related to the formation of organo-mineral (such as allophanic materials) complexes and/or organo-metallic (Al and Fe) complexes, physical protection of SOM by high porosity of the soils, and the low activity of soil microorganisms due to the low soil pH and the high level of toxic Al. Among the factors affecting SOM accumulation, the Al-humus complexes are considered to be the most important. Nanzyo et al. (1993) confirmed the close correlation (r = 0.84, P < 0.01) between pyrophosphate-extractable Al and organic carbon (OC) concentration in A horizon soils using data from the Andisol Tohoku University Database (Shoji et al. 1993). In this study, to assess the other factors including soil pH, aluminum toxicity, or short-range-ordered minerals for the accumulation of OC, we performed a path analysis using the database.

Materials and Methods

Database: We used the Tohoku University World Andosol Database (2002 version) that is the revised version of the Andisol Tohoku University Database (Shoji et al. 1993). From the database, we extracted 293 humus horizons (A or buried A horizons) of volcanic soils distributed in Chili, Ecuador, the California and Alaska States of the U.S.A., New Zealand, Indonesia, Taiwan and Japan.

Statistical Analysis: The path diagram in Fig. 1 was used to examine the causal path of selected soil properties to the OC content. The selected explanatory variables included the pH(H_2O), 1 M KCl-extractable aluminum (KCl-Al), sodium pyrophosphate-extractable Al and Fe (Al_p and Fe_p), and acid oxalate-extractable Si (Si_o). The direct effects of the soil properties on the OC are termed "path coefficient" and are standardized partial regression coefficients for each of the soil properties in the multiple linear regression versus the OC. The indirect effects of the soil properties on the OC were determined from the products of the simple correlation coefficient between the soil properties and the path coefficient.

Results The path analysis showed that a high correlative coefficient between the OC content and Al_p (r = 0.69, P < 0.01) was mainly explained by the direct effect of Al_p (0.52, P < 0.01) on the OC content. Strong correlations between OC and KCl-Al (r = 0.60, P < 0.01) or pH(H_2O) (r = -0.58, P < 0.01) were due not only to the direct effect (0.21 and -0.27, respectively, P < 0.01), but also to the indirect effects of other properties, especially that of Al_p. Thus, it is considered that, in the humus horizons of the Andosols, the Al-humus complexation mainly contribute to the OC accumulation, and the low soil pH values and Al toxicity partly relate to the humus reservation by depressing the microbial activity.

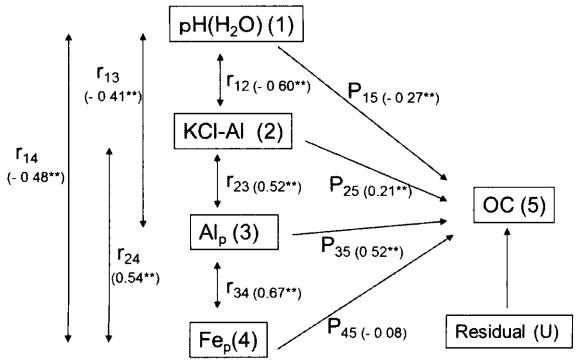

Fig. 1. Path analysis diagram for the relationships between organic carbon (OC) content and soil properties. The path coefficient (P_{ij}) of soil properties is represented by single-headed arrows, and the simple correlation coefficients (r_{ij}) between variables are represented by double headed arrows. **Significant at P < 0.01.