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Investigation of the spatial heterogeneity of soil microbial biomass carbon and nitrogen under long-term fertilizations in fluvo-aquic soil

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Abstract

Soils are heterogeneous and microbial spatial distribution can clearly indicate the spatial characteristics of the soil carbon and nitrogen cycle. However, it is not clear how long-term fertilization affects the spatial distribution of microbial biomass in fluvo-aquic soil. We collected fluvo-aquic soil samples (topsoil 0–7.5 cm and sub-topsoil 7.5–20 cm) using a spatially-explicit design within three 40.5 m^2 plots in each of four fertilization treatments. Fertilization treatments were: cropping without fertilizer inputs (CK); chemical nitrogen, phosphorus, and potassium fertilizer (NPK); chemical fertilizer with straw return (NPKS); and chemical fertilizer with animal manure (NPKM). Variables included soil microbial biomass carbon (MBC) and nitrogen (MBN), and MBC/MBN. For both soil layers, we hypothesized that: microbial biomass was lowest in CK but with the largest spatial heterogeneity; and microbial biomass was highest in NPKM and NPKS but with the lowest spatial heterogeneity. Results showed that: (1) Fertilization significantly increased MBC and MBN more in topsoil than sub-topsoil but had no MBC/MBN changes. (2) The coefficient of variation (CV) and Cochran's C showed that variation was largest in CK in topsoil and NPK in sub-topsoil and that variation of topsoil was generally lower than in sub-topsoil. The sample size of the three variables was largest in CK in topsoil but had little variation among the other treatments. (3) The trend-surface model showed that within-plot heterogeneity varied substantially with fertilization (NPKM = NPK > NPKS > CK), but Moran's I and the interpolation map showed that spatial variability with fertilization followed the order NPK > NPKS > CK = NPKM at a fine scale in topsoil. In sub-topsoil, the trend-surface model showed that within-plot heterogeneity followed the order NPKM = CK > NPK > NPKS and that the fine-scale pattern was NPKM>NPK = NPKS>CK. MBC had the highest spatial heterogeneity among the three variables in both soil layers. Our results indicate that the application of organic fertilizer (straw or manure) reduced the variation of MBC and MBN but increased the spatial variability of MBC and MBN. The spatial variation of the three variables was MBC > MBN > MBC/MBN regardless of whether variation was considered at the plot-scale or the fine-scale in both layers.