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A simple assessment on spatial variability of rice yield and selected soil chemical properties of paddy fields in South China

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ABSTRACT

Data related to the spatial variability of properties of paddy soil is critical for improving rice productivity and designing sustainable farming techniques. However, a systematic assessment focusing on the spatial variability of low-yield paddy soil has not been conducted in South China. In this context, 560 soil samples were collected across South China and analyzed for nine common chemical properties. Rice yield data was obtained by surveying farmers during soil sampling. Soil parameters and rice yield varied considerably throughout the study area and their coefficients of variation ranged from 17.3% to 74.2%. Experimental semivariograms were developed and a moderate spatial dependence was observed for all selected parameters. Distribution maps, derived by kriging interpolation, illustrated that these paddy fields were characterized by high concentrations of soil organic matter (SOM), total N (TN), available N (AN) and available Zn (AZn); pH values decreased widely comparing with the data reported by the National Soil Survey, especially in southeast China; the areas with low soil P concentrations (<10 mg kg^{-1}) were mainly located in southwest China; cation exchange capacity (CEC), available K (AK) and available Si (ASi) had similar trends in spatial distributions with high concentrations in southeast China and low concentrations in southwest. Notably, paddy fields in southeast China were typically deficient in AK due to their concentrations, all of which are almost less than 100 mg kg^{-1}. Correlation analysis revealed that rice yield was significantly positively correlated with pH, CEC, AK and ASi, while negatively correlated with AN and AZn. Low pH, AK, CEC and ASi levels may be the most important constraints limiting rice productivity and fertilizers with N and Zn may be over-used and must be applied appropriately. The soil quality index (SQI) was also calculated using the analyzed chemical properties and a significant correlation was observed between SQI and rice yield, supporting earlier findings that good soil chemical health is essential for optimum sustained crop production. The remarkable variations of SQI and rice yield indicated that the potential for increasing rice productivity is a real prospect. Therefore, regional planning fertilization should pay more attention to the spatial variability of soil chemical properties to avoid economic losses and environmental pollution, and especially to the limited nutrients.

1. Introduction

Soil chemical properties are typically related to variability in crop yield (Bouma and Finke, 1993) and their degradation will result in a decrease of levels of soil fertility, nutrients and thus productivity (Gray and Morant, 2003). Scientific information concerning spatial variability and distribution of soil properties is critical for farmers attempting to increase fertilization efficiency and crop productivity (Mabit et al., 2008; Tesfahunegn et al., 2011a); fertilization based on large scale maps with recommendations related to soil fertility may also lead to reduced fertilizer inputs without reducing yield (Jalali, 2007). Therefore, assessing the spatial variability of soil chemical properties is crucial to efforts designed to introduce sustainable cropping systems, especially for developing countries such as China.

Paddy soil is the most important arable soil type in South China, while low-yield paddy soil accounts for 26% of the area of all paddy fields (Xiao, 1981). Improving their productivity is considered to be an effective means of ensuring national food security due to the large area (Xu and Zhong, 2010). China has experienced long-term application of chemical fertilizers in the last 30 years with general overuse (Zhang et al., 2008). Many changes have occurred in soil attributes, particularly in chemical properties (Lu et al., 2000). Those changes have raised concerns about the long-term sustainability of China's intensively cultivated agricultural systems (Huang et al., 2007). However, a large amount of chemical fertilizer will continue to be used to sustain crop production in the coming decades (Zhu and Jin, 2013). Knowing how to achieve appropriate fertilization remains a challenge in agricultural

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