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Irrigation regime affected SOC content rather than plow layer thickness of rice paddies: A county level survey from a river basin in lower Yangtze valley, China

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ABSTRACT

While the impacts of farm management practices such as fertilization, tillage and straw return on soil organic carbon dynamics in croplands have been widely studied, the effects of irrigation management in irrigated rice paddies have not yet been widely assessed. Changes in plow layer thickness and soil organic carbon content of rice paddies were analyzed using data obtained in a county-level survey of soil fertility conducted in 2005 and 2006 in Guichi County, Anhui Province, China. Both soil thickness and organic carbon content of plow layer showed skewed normal distributions, with their averages of 14.58 ± 3.92 cm, and 16.45 ± 6.02 g/kg, respectively. The irrigation method was found to have significant influences on both plow layer thickness and soil organic carbon content, as the plow layer thickness and soil organic carbon content had an inverse response to the irrigation intensity derived from different irrigation methods. The land-level performance of irrigation/drainage infrastructure and the irrigation water sources were detected to have significant effect on plow layer thickness, but little influence on soil organic carbon content. While the capacity of irrigation/drainage infrastructure had a remarkable effect on soil organic carbon content but little impact on plow layer thickness. However, the irrigation condition for surveyed fields was detected to have little effect on both plow layer thickness and soil organic carbon content. These results indicated that irrigation management should keep the balance between surface erosion on plow layer thickness and soil organic carbon accumulation. Hence, developing new technique for good irrigation infrastructure and water management in future will help soil organic carbon accumulation as well as improve the soil for enhanced crop growth in rice agriculture.

1. Introduction

Rice is grown on almost 155 million hectares of the earth's surface, more than 90% of the world rice is planted in Asia, and nearly 80% of the rice fields are managed as paddy soil, corresponding to 139.62 million hectares in 2008 (Kögel-Knabner et al., 2010). More than half of the rice paddies need irrigation during their growing season (Bouman and Tuong, 2001; Maclean et al., 2002). Irrigated rice can deliver high and stable yields (Lu et al., 2000; Bouman and Tuong, 2001; Bouman et al., 2005; Li et al., 2012) and produces about 75% of the world's rice supply (Maclean et al., 2002). Irrigation with continuous flooding has raised concerns for high levels of seepage and lower water productivity (Bouman and Tuong, 2001; Bouman et al., 2005), with additional loss of water-soluble nutrients (Zhang et al., 2003; Yoon et al., 2006; Jang et al., 2012). Wissing et al. (2013) reported that water logging associated with rice cropping enhances accumulation of soil organic carbon (SOC) due to the lower SOC decomposition rates under generally anaerobic conditions (Sahrawat, 2004) and greater inputs of OC (Gong and Xu, 1990; Tanji et al., 2003; Yang et al., 2005; Li et al., 2010) compared to non-irrigated soils. However, irrigation with flooding could enhance clay migration in addition to a decline in redox potential (Kögel-Knabner et al., 2010; Li and Horikawa, 1997; Li et al., 1997), and in turn a decline in topsoil thickness in the long term (Chen et al., 2013; Long et al., 2006).

Of the total area of 30 Mha of China, most irrigated rice paddies are distributed in its southern part (Xu et al., 2011), especially in the lower Yangtze Valley (Cao and Zhang, 2004; Lin et al., 2004). High rates of topsoil SOC accumulation in rice paddies

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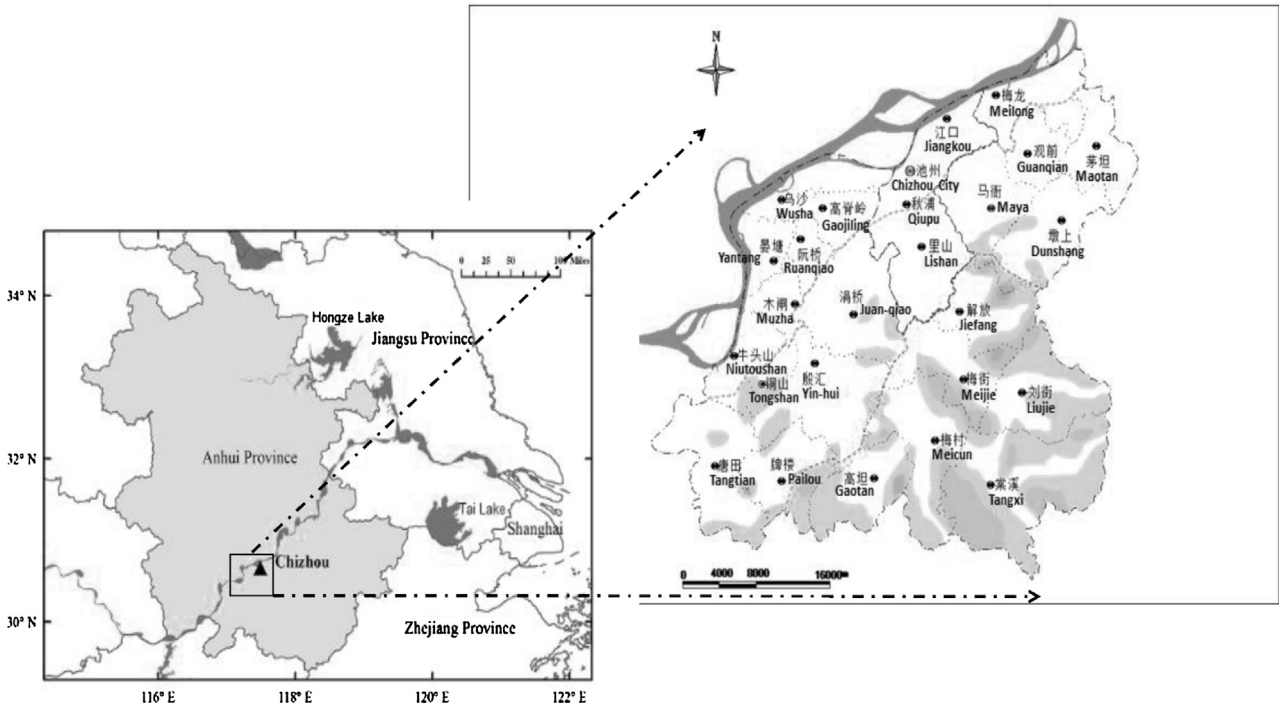

Fig. 1. The studied area of Guichi County, Anhui Province, China showing the Yangtze River in gray and rice paddies in blank.

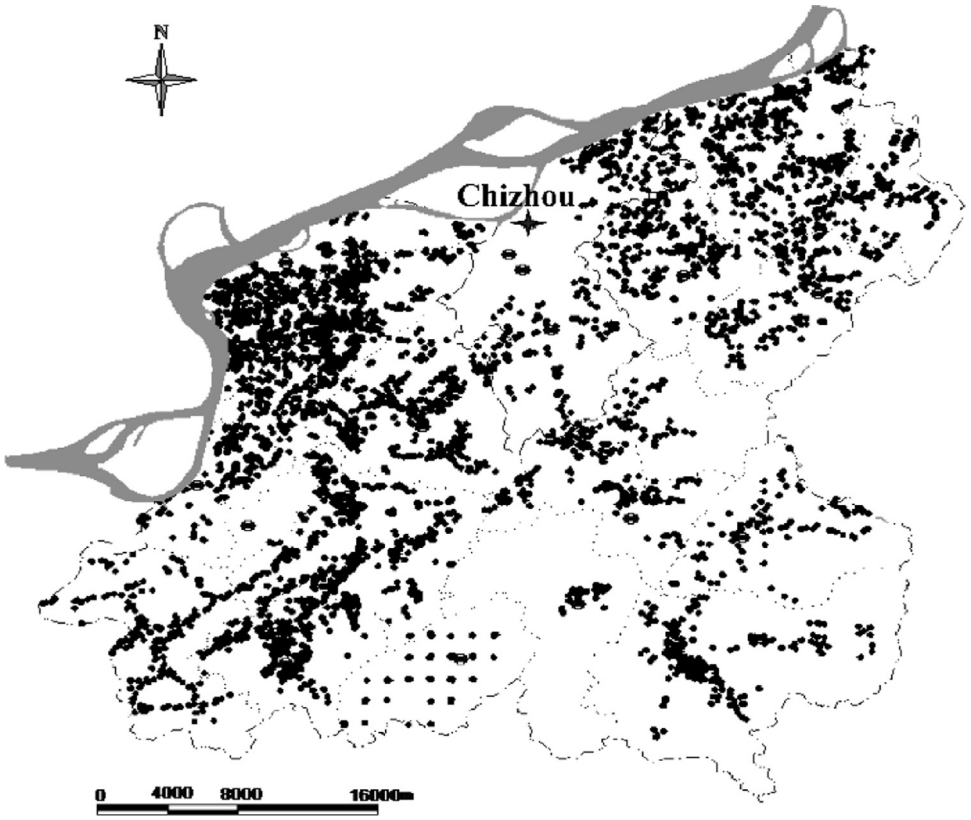

Fig. 2. The sites of topsoil sampling in Guichi County, Anhui Province, China showing the Yangtze River in gray and sampling sites in black plots.

have been noted (Pan et al., 2004; Zhang et al., 2007) and SOC dynamics in rice paddies from these areas have been well studied with respect to fertilization (Zhou et al., 2016; Wang et al., 2010), conservation tillage (Hou et al., 2012; Wang et al., 2009) and other recommended management practices (Rui and Zhang, 2010). Recent research indicated that different water management practices exert an important impact on dissolved organic carbon cycling in rice paddies (Said-Pullicino et al., 2015). However, the effects of irrigation management on topsoil depth and SOC dynamics have not been adequately addressed.