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Cross-ridge tillage decreases nitrogen and phosphorus losses from sloping farmlands in southern hilly regions of China

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ABSTRACT

Losses of nutrients, water and soil from sloping farmlands have a large potential to contribute to water eutrophication and land degradation. However, few long-term and multi-site measurements are available to assess the magnitude of effects of cross-ridge tillage on surface runoff and nitrogen (N) and phosphorus (P) losses from sloping farmlands. Field experiments were conducted under natural rainfall conditions for six to seven years across four experimental sites in southern China. Each site-year experiment consisted of three management practices: downslope ridge without fertilizer as control (CK), downslope tillage with fertilizer (DF), and cross-ridge with fertilizer (CF). Results indicated that compared to the downslope tillage practice, cross-ridge tillage reduced the average annual runoff by 6.11% to 64.2%. Compared with DF, CF significantly decreased total N (TN) and total P (TP) losses by 11.3% to 69.7% and 15.9%- to 63.5%, respectively ($P < 0.05$). The decreases in TN and TP losses were significantly associated with sediment yield reduced by cross-ridge, which significantly reduced both particulate N and particulate P losses. While TN loss in CF was dominated by total dissolved N (62.4%), particulate P accounted for 68.4% of TP in runoff. Across all tillage practices, N and P losses increased at higher soil N and P contents, indicating the necessity of adopting crop and nutrient management practices to reduce soil nutrient levels and thus nutrient losses from sloping farmlands. Despite regional and temporal variabilities, cross-ridge tillage consistently reduced surface runoff, sediment yield, and N and P losses compared with downslope tillage. In conclusion, cross-ridge tillage is an effective conservation measure to reduce soil erosion and nutrient losses from sloping farmland in China's hilly regions.

1. Introduction

Sloping farmland is a valuable land resource, especially in hilly agricultural areas. Nonetheless, soil erosion and losses of soil nutrients from sloping farmland are frequently reported as a threat to water quality and agricultural productivity worldwide (Pimentel, 2006; Wei et al., 2007; Durán Zuazo and Rodríguez Pleguezuelo, 2008; Zhao et al., 2015a). Sloping farmland is often featured by greater nutrient losses in surface runoff resulting from applications of chemical fertilizers and manures compared to flat landscape (Bah et al., 2014). In addition, agricultural operations, such as tillage on sloping farmland, can affect soil roughness, which can eventually alter field hydrology and affect nutrient runoff (Takken et al., 2001; Zhao et al., 2018). Indeed, a number of studies have demonstrated that soil erosion and nutrient losses are elevated by intensive agricultural operations (Guo et al., 2008; Basic et al., 2001, 2004; Wang et al., 2017). Therefore, understanding the impact of agricultural practices on sediment and nutrient losses in runoff is very important for exploring best management practices that could effectively control the risk of soil erosion and nutrient losses from sloping farmlands.

Ground surface characteristics and rainfall patterns are two key factors influencing the extent of water erosion from sloping farmland (Wei et al., 2014; Zhou et al., 2016b). Improving microtopography (e.g., by contour tillage and ridge culture), implementing conservation tillage (e.g., no/minimal tillage), and increasing surface coverage (e.g., by straw mulching and film mulching) are popular practices for retaining water and soils on sloping farmland. Indeed, many methods have proven to be effective in preventing water and soil losses.

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