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Effects of Napier grass management on soil hydrologic functions in a karst landscape, southwestern China

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ABSTRACT

Soil hydrologic functions are important for ecological restoration in karst landscapes where soil and water loss are serious. For examining how different strategies of Napier grass cultivation affect soil hydrologic function, and to identify reasonable strategies for maintaining soil hydrologic function, this study investigated the effects of 3 years' (since 2011) Napier grass (*Pennisetum hydridum*) management on soil hydraulic properties (soil field-saturated hydraulic conductivity (K_{fs}), water retention parameter (α)) using an orthogonal experiment (form $L_{12}(4^2 \times 3^1)$) in 2014. The management experiments included three levels for each of the following: nitrogen fertilization, cutting frequency and cutting intensity. Results showed that the farming practices (nitrogen fertilization, cutting frequency and cutting intensity) of Napier grass had higher influence on the soil hydraulic properties of the topsoil than those of the subsoil; nitrogen fertilization influenced the soil hydraulic properties more significantly than cutting frequency and cutting intensity. The K_{fs} of the topsoil generally decreased with increasing nitrogen fertilization and cutting frequency. This study suggests that the implementation of different farming practices differently alters soil hydrologic functions. Hence, in karst landscapes where water resources are limited for agricultural production, the selection of optimal farming practices for high productivity should also take soil hydrologic functions into consideration.

1. Introduction

The Chinese government initiated a "Grain for Green" program in the late 1990s/early 2000s. This program has increased the greenness and associated ecological benefits (e.g. carbon sequestration) across China (Song et al., 2014; Lu et al., 2015). Napier grass (*Pennisetum hydridum*), is one of the commonly used plant types for the "Grain for Green" program in karst landscapes (Liang, 1999), also known as elephant grass or Uganda grass, which is a species of perennial tropical grass native to the African grasslands and widely planted in the Guangxi province in southwest China. Local farmers commonly use different management (e.g., fertilization and cutting) for Napier grass in order to maintain soil nutrients (Yu, 2007) and keep high yields.

The management practices of Napier grass are somewhat more intensive than those of cereal crops, vegetables, fruit trees and timber trees. For example, the annual amounts of fertilizers (200 kg N ha^{-1} yr^{-1}) applied to Napier grass are usually higher than those applied to other plants. Moreover, the cutting intensity (cutting biomass) and frequency (cutting times) of Napier grass are usually higher than those for cereal crops and trees. Most previous studies mainly focused on the impacts of different management on Napier grass productivity (Rengsirikul et al., 2011; Peng et al., 2012; Liang et al., 2013), and a few studies also assessed how different management strategies of Napier grass affect soil biological functions (Zhao et al., 2014). However, little is known about if and how different management strategies affect soil hydrologic functions that are very important for karst landscapes where water is a limited factor for ecosystem management and restoration. Soil field saturated hydraulic conductivity (K_{fs}) and the water retention parameter (α) are important hydraulic properties describing soil

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hydrologic functions, since they control the hydrologic and soil erosion processes, such as infiltration rate and runoff production (Pirastru et al., 2013). Droughts and floods are frequent and serious problems in karst areas of the Guangxi province (Zhou et al., 2012). Soil with high K_{fs} decrease flooding hazards and soil with good water retention capacity contribute to counteract the negative effects of droughts. Thus K_{fs} and α are both vital indicators for soil health, but few studies have focused on these indicators.

This study therefore aims to examine how different management strategies of Napier grass affect soil hydrologic functions, and to identify reasonable management strategies (including different management levels) maintaining good soil hydrologic functions. Those findings in this study may be helpful in ecological restoration and management for karst landscapes.

2. Materials and methods

2.1. Study area

The experiment was carried out in the Huanjiang Observation and Research Station for Karst Ecosystems (24°44′–25°33′N, 107°51′–108°43′E) of the Chinese Academy of Sciences (CAS), located in the northwest Guangxi Province, China Fig. 1. The climate in this area is dominated by subtropical monsoon. The mean annual temperature and precipitation are 18.5 °C and

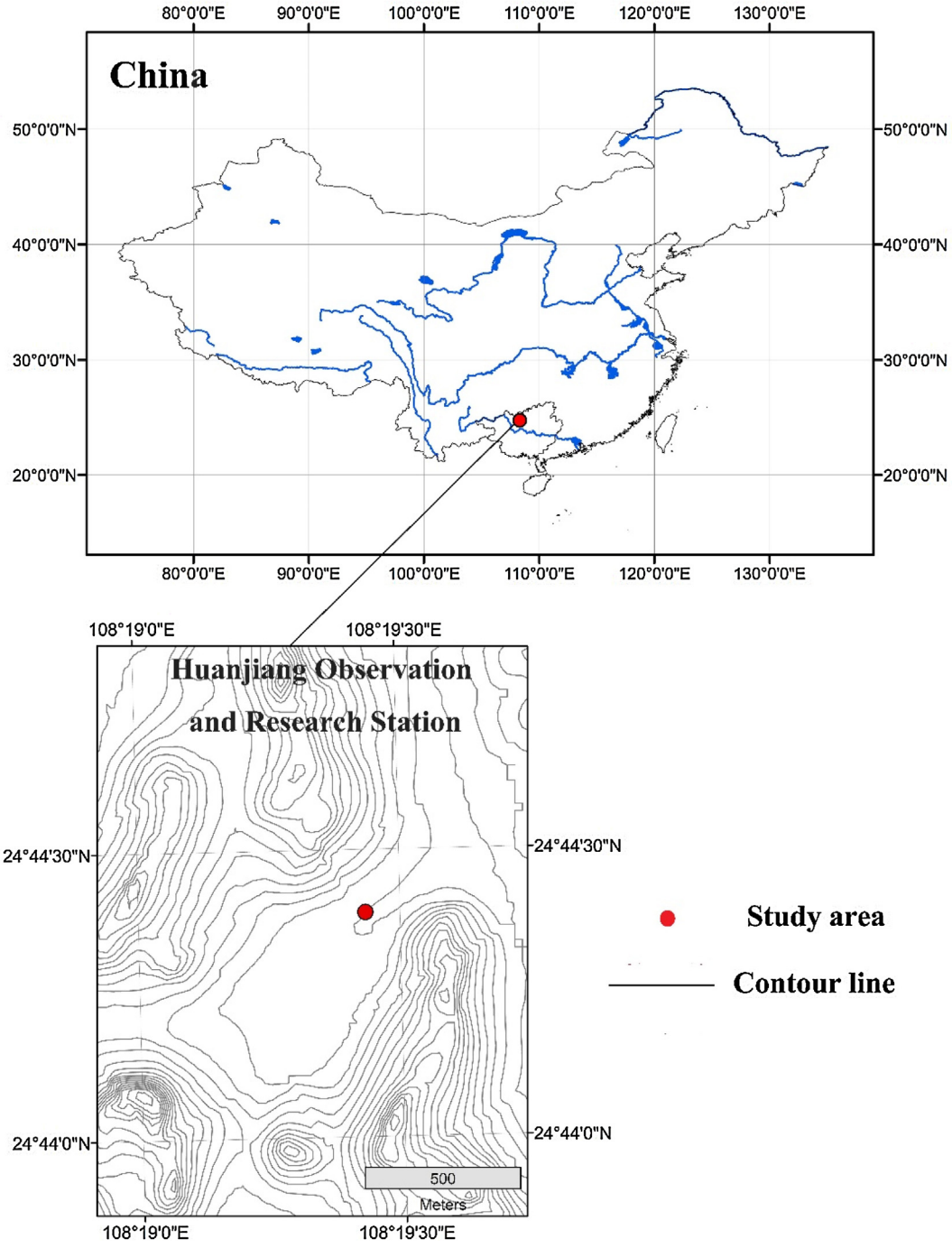

Fig. 1. The location of the study site in Huanjiang, Guangxi, China.