Agricultural Water Management 97 (2010) 1971–1977

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

Effect of brackish water irrigation and straw mulching on soil salinity and crop yields under monsoonal climatic conditions

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ARTICLE INFO

Article history:
Available online 27 September 2009

Keywords:
Accumulation
Salt balance
Soil
Winter wheat
Summer maize

ABSTRACT

Fresh water shortages are severally restricting sustainable agriculture development in the North China Plain. The scarcity of fresh water has forced farmers to use brackish water from shallow underground sources, which helps to overcome drought and increase crop yields but also increases the risk of soil salinization. To identify safe and effective ways of using brackish water in this region, field experiments were conducted to evaluate the effect of brackish water irrigation and straw mulching on soil salinity and crop yield in a winter wheat–summer maize double cropping system. The experiment was in a split-plot design. Six rates of straw mulching (0, 4.5, 6.0, 7.5, 15.0 and 30.0 Mg/ha) were assigned to the main plots and two irrigation water qualities (i.e. brackish water with salt content of 3.0–5.0 g/L and fresh water with only 1.27 g salt/L) were applied to subplots. The brackish water irrigation significantly increased the salt content at different soil depths in the upper 1 m soil layer during the two growing seasons. Straw mulching affected the vertical distribution of salt in the brackish water irrigation plots and the average salt content of straw mulch treatments (4.5, 6.0, 7.5, 15.0 and 30.0 Mg/ha) within the 0–20, 20–40 and 0–100 cm soil depths was 10.2, 14.0 and 1.8% lower than that without straw mulch (A_0). No salt accumulation occurred to a depth of 1 m in the brackish water irrigation plots and there was no correlation between the value of SAS (salt accumulated in 1 m of soil) and straw mulch rate. In 2000 and 2001, the salt content within the 0–40 cm soil layer in brackish water irrigation plots increased due to high evaporation rates during April–June, and then decreased up to September as salts were leached by rain. For the fresh water irrigation plots, the salt content remained relatively stable. Straw mulching affected the salt content in the 0–40 cm soil layer in brackish water irrigation plots in different periods of 2000 and 2001, but no correlation between salt content and straw mulch rates was observed except in September of 2000. Unlike for wheat, the yield of maize increased as the straw mulch rate increased according to the equation, $y = 0.1589x + 5.3432$ ($R^2 = 0.6506$). Our results would be helpful in adopting brackish water irrigation and straw mulching in ways that enhance crop yields and reduce the risk of soil salinization. However, long-term effects of brackish water irrigation and straw mulching on soil salinity and crop yield need to be further evaluated for sustainability of the system.

1. Introduction

Production levels of winter wheat–summer maize cropping system in the North China Plain (NCP) (Fig. 1) depend largely on irrigation. Farmers obtain irrigation water by pumping groundwater located at depths between 200 and 300 m, and have caused a rapid decline at these depths (Ma et al., 2008). Because the availability of fresh groundwater resources for irrigation is limited, recent emphasis has been on exploring the use of non-conventional water resources. It was estimated that the fossil aquifer in many areas of the NCP contained 54 billion m^3 of brackish water (MWR, 1998) with a salt content ranging from 2 to 5 g/L, and a static water depth of 10–20 m. Until recently, this water was not considered suitable for agricultural irrigation because of its high salt content. However, the current water scarcity in these regions has forced farmers to explore the possibility of utilizing brackish water for irrigating agricultural crops.

Brackish water could be used for irrigation and was beneficial to crop production (Rhoades et al., 1980; Awan and Latif, 1982; Grattan et al., 1987; Rains et al., 1987; Sharma et al., 1991; Rhoades et al., 1992; Minhas and Bajwa, 2001; Patel et al., 2003; Sharma and Minhas, 2005; Ma et al., 2008). Various strategies have been proposed to use such waters for irrigation (Rhoades, 1984; Rhoades, 1987; Boumans et al., 1988; Westcot, 1988; Sharma et al., 1991; Yan

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doi:10.1016/j.agwat.2009.08.020