Geoderma 365 (2020) 114213

Contents lists available at ScienceDirect

Geoderma

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

Water and salt exchange flux and mechanism in a dry saline soil amended with buried straw of varying thicknesses

Hongyuan Zhang, Huancheng Pang, Yonggan Zhao, Chuang Lu, Na Liu, Xiaoli Zhang, Yuyi Li*

Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081, China

ARTICLE INFO

Keywords:
Straw layer
Thickness
Soil moisture
China
Salt flux
Saline soils

ABSTRACT

Salt stress severely constrains crop productivity in arid lands of the world. Burying straw at the 40 cm soil depth plus plastic film mulching could mitigate root zone salinity, but little is known about how the thickness of buried straw affects soil water and salt transport. Therefore, a three-year field experiment was conducted from 2010 to 2013 to address this issue, with treatments including: compacted straw thickness of 3 cm (T3), 5 cm (T5), or 7 cm (T7) (corresponding to straw application at rates of 6, 12 and 18 t ha^{-1}, respectively). In addition, a supplementary experiment, which included treatments of no buried straw layer (CK) and 5 cm of compacted straw layer thickness (t5) in the same micro-plot experiment, was carried out from 2014 to 2016 to identify soil pore structure and hydraulic parameters after three years of deep straw burial. Results showed that the initial soil water content increased with increasing thickness but significantly ($P < 0.05$) decreased in later periods. Soil salinity consistently decreased with increasing straw thickness, and T7 was most effective for improving salt leaching. However, the water and salt regulation under T5 gradually decreased mainly due to the change in saturated water conductivity and porosity among layers. After irrigation, the flux of salt leaching (FL) increased with straw thickness, and the FL under T7 significantly exceeded that under T3 by 105, 89 and 33% and that under T5 by 84, 66 and 33% in 2011, 2012 and 2013, respectively. The salt flux during evaporation under T7 was much higher ($P < 0.05$) than that under T3 and T5 by 92 and 10% in 2012 and 38, 44% in 2013. At harvest, salt storage within the soil consistently ranked as T3 > T5 > T7. Although T7 had the most pronounced effect on salt mitigation, it was difficult to implement under normal field conditions. Thus, for relatively good water infiltration, salt leaching and inhibition of salt return, straw buried to a thickness of 5 cm is recommended.

1. Introduction

Soil salinization is an ecological disaster that causes degradation of soil quality, especially in arid and semi-arid areas. This problem is listed among the major ecological and economic issues in the world (Qadir et al., 2000). At present, the global salinized land area is about 1 billion ha, constituting one of the most pressing challenges to sustainable use of soil resources (Chernousenko et al., 2017). In China, the total area of saline-alkali and secondary saline-alkali land amounts to 36 million ha, accounting for nearly 5% of the global salinized land area (Yang, 2008). Since the saline-alkali land accounts for one fourth of the cultivated land in China, rational use and mitigation of saline soil resources are essential to alleviate the increasing food insecurity (Wang et al., 2013; Yang et al., 2019).

To mitigate the effects of salt stress on plants, humans seek to leach soils by flooding or drip irrigation with fresh or brackish water to reduce the salt content in the surface soil (Qadir et al., 2000; Kang et al., 2012; Fan et al., 2012a). However, the salts in the deep soil layers and shallow groundwater could move upward and accumulate in the surface soil through a capillary process. To solve this problem, establishment of interlayer in the subsoil is needed as it could act as an effective barrier to capillary movement and improve soil quality in saline-alkali areas (Akudago et al., 2009; Zhang et al., 2016). The capillary barrier, consisting of sand, gravel, or coarse layer, is important for infiltration of irrigation water in soil strata (Fredlund et al., 2002; Kampf et al., 2003; Guo et al., 2006, 2007; Jia et al., 2006), preventing salt accumulation in the surface soil, and consequently alleviating salt stress on crops (Sun et al., 2011). When other conditions are constant, the interlayer thickness is one of the determinants for the maximum rise of the capillary water in layered soils (Wang et al., 2014). The thicker the interlayer, the longer the retention time of the capillary water in the interior, and the more effective of the interlayer in inhibiting water

* Corresponding author.
E-mail address: liyuyi@caas.cn (Y. Li).

https://doi.org/10.1016/j.geoderma.2020.114213
Received 18 June 2019; Received in revised form 12 January 2020; Accepted 20 January 2020
0016-7061/