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Application of the SWAP model to simulate water–salt transport under deficit irrigation with saline water

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ABSTRACT

The agro-hydrological Soil–Water–Atmosphere–Plant (SWAP) model was calibrated and validated to simulate water–salt transport based on field experiments in an arid region of China. The simulation results show lower soil water content but higher salt concentration under deficit irrigation. Soil water and salinity below 95 cm at 80% evapotranspiration (ET_c) treatments and 65 cm at 60% ET_c treatments were hardly affected by irrigation. With deficit irrigation, the maximum water uptake and salt accumulated layer moved upward. The SWAP model was also used to predict long-term deficit irrigation with saline water. The salinization process reached equilibrium after utilization of saline water for a few years. In summary, the numerical model proves to be a useful tool for studying water–salt transport under different scenarios and for evaluating irrigation practices for a long period.

1. Introduction

The Shiyang River basin is a typical interior river basin that faces water shortage and environmental deterioration in arid Northwest China [1]. Agriculture in this area relies largely on irrigation. The use of saline groundwater for irrigation is unavoidable because of the rising water demand and deterioration in groundwater spread. Shani et al. promoted deficit irrigation for regions using poor-quality water [2]. Deficit irrigation with saline water should also be extended to the area. The soil water–salt dynamics is basic in studying the genesis, evaluation, and control of soil salinity [3–6]. Saline water management is usually based on maintaining the root zone salinity below its threshold value and on alleviating the effects on crop yield [7,8]. Research indicates that deficit irrigation with saline water decreases the water loss and salt accumulation, but it alters the water extraction and salt accumulation pattern in the soil profile [9]. Therefore, evaluating the effects of deficit irrigation with saline water on soil water–salt transport is important in establishing appropriate water management practices. The soil water–salt dynamics is complex when crops are irrigated with saline water.

The use of field experiments is the most credible technique for studying soil water movement and salt accumulation, but it is time consuming and expensive. Given this, numerical models have played an increasingly important role in the study of water flow and solute transport process in unsaturated zones [10–15]. The Soil–Water–Atmosphere–Plant (SWAP) model is a deterministic one-dimensional model for water, heat, and solute transport [16]. It has been applied at different scales in different places around the world to address management practices and their impact on crops and the environment [17–22]. However, the SWAP model has not been applied in the simulation of water–salt transport under deficit irrigation with saline water and long-term prediction in arid Northwest China.

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