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Effects of different irrigation management parameters on cumulative water supply under negative pressure irrigation

JiaJia Wang[a,b,c,1], HuaiYu Long[b,*], YuanFang Huang[c], XiangLing Wang[d], Bin Cai[e], Wei Liu[e]

[a] State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, PR China
[b] Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081, PR China
[c] Department of Soil and Water Sciences, College of Resources and Environmental Sciences, China Agricultural University, Key Laboratory of North China Cultivated Land Conservation, MOA, Beijing 100193, PR China
[d] Linshu county bureau of Agriculture and Rural Affairs, Linyi city, Shandong 276700, PR China
[e] Henan Qingshuiyuan Technology Co., Ltd, Henan 454672, PR China

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ABSTRACT

The pressure of the water supply is controlled to a negative value relying on soil matric suction and is called negative-pressure irrigation (NPI), a subsurface irrigation method used to improve water use efficiency; however, the impacts of initial soil water conditions and emitter hydraulic conductivity on water movement under NPI remain unknown. To study the effects of irrigation management parameters on water movement under NPI, 300 scenarios using different soil textures, initial soil matric potentials, emitter hydraulic conductivities, negative pressure inside emitter and time were simulated using the Hydrus-2D software package. The effects of these variables on water movement under NPI were analyzed following the simulations, and a empirical model was created to quantify the cumulative water supply based on initial soil matric potential, emitter hydraulic conductivity, negative pressure inside emitter, and time. The results showed that the cumulative water supply increased as the emitter hydraulic conductivity increased or initial soil matric potential decreased. The relationships between the cumulative water supply and both the hydraulic conductivity of the emitter wall and the absolute value of the initial soil matric potential were logarithmic. Cumulative water supply had exponential and linear relationships with the absolute value of the negative pressure inside emitter and time, respectively. The empirical model created to quantify the cumulative water supply under NPI yielded estimations that were in good agreement with the measured values. Therefore, this model can be applied to calculate water supply under NPI, providing a smiple and reliable tool for future NPI applications and management.

1. Introduction

Subsurface irrigation can effectively improve water use efficiency by supplying water directly to the crop root zone. The process in which the pressure of the water supply is controlled to a negative value relying on soil matric suction and is called negative-pressure irrigation (NPI) (Moniruzzaman et al., 2011a, b; Tanaka and Kojima, 2006). Consequently, NPI can regulate soil moisture precisely and continuously, improving crop productivity by controlling root zone soil water and solute content at optimal levels for crop growth via irrigation pressure and emitter hydraulic conductivity control (Abu-Zreig et al., 2006; Khan et al., 2013; Zheng et al., 2013). NPI can also reduce surface evaporation, runoff, and deep seepage loss over the growing season compared to traditional drip irrigation methods (Moniruzzaman et al., 2011a, b). The continuous and stable water supply produced by NPI has been results in improved plant height, stem diameter, fruit yield, and water use efficiency compared to drip irrigation (Li et al., 2017; Nalliah et al., 2009). Moreover, because NPI integrates water and fertilizer delivery, it is appropriate for vegetable production in solar greenhouses (Abidin et al., 2014; Hack, 1971; Libby et al., 2018; Nalliah and Ranjan, 2010).

A number of NPI irrigation management parameters are crucial for determining the cumulative water supply and the wetting zone. For example, Wang et al. (2017) simulated water movement during NPI using the Hydrus-2D software package and found that soil wetting body volume, soil water content, and water infiltration increased with

* Corresponding author.
E-mail addresses: jiajia19202080@163.com (J. Wang), mailto.longhuaiyu@caas.cn (H. Long), yfhuang@cau.edu.cn (Y. Huang), wangxiangling1989@yeah.net (X. Wang), caibin@qsysh.com (B. Cai), familylw@163.com (W. Liu).

[1] State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, PR China.

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