Chapter 25

Root Water Uptake Model of *Populus Euphratica* in Desert Riparian Forest in Extreme Arid Region

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**ABSTRACT**

Plant root water uptake is a key way to transfer soil water to the atmosphere. It is an important part of the research on water transforming patterns in the SPAC (Soil-Plant-Air Continuum). So understanding the water absorption patterns of plant root system is a base to recognize the SPAC. Recently there are many studies on the water absorption patterns of plant root system. However, the researched plants are mostly crops and the main researched areas are regions with adequate precipitation. There are only a few studies on the water absorption of natural plants in extreme arid desert regions. This paper studied the root water absorption patterns of *Populus euphratica* and established the corresponding mathematical model based on the data of root density and soil water dynamics in root zone in desert riparian forest in extreme arid region. The finite difference method was used to discretize the soil water movement equation with evaporation boundary conditions. Numerical simulation analysis of soil water movement in root zone of *Populus euphratica* showed that the simulated values were consistent with the measurement values with 92-98% precision. This work provides a theoretical basis for the study of water movement in the SPAC.

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INTRODUCTION

Root water uptake is an important process of water cycle and an important part of the research on water transforming patterns in the SPAC (Soil-Plant-Air Continuum). A quantitative means of describing root water uptake may help guide efficient water use (Gong et al., 2006). The research on the water uptake model of plant roots was started in the 1940’s. Van den Honert (1948) put forward the theoretical pattern of water flow, which established the model of root water-uptake mechanism. Gardner (1960) developed the first single-root water uptake model. Afterwards, many different models were developed, among which the water-uptake models proposed by Molz & Remson (1970), Nimah & Hanks (1973), Feddes et al. (1976, 1978), Hillel et al. (1976), Raats (1975), Herlelraith et al. (1977) and Molz (1976, 1981), had broadened and improved the model. Since the beginning of the 1960’s, a number of scholars have improved the acquisition of parameters involved in root water-uptake models and the measurement methods. They also established the two and three-dimensional models. Green (1997; 1999) established the root water uptake model of apple trees. Vrugt et al. (2001) developed the two and three-dimensional models of almond trees, and compared them in detail. Pagesl (1989) and Diggie (1998) constructed the three-dimensional models. These models mostly consist of three quantitative descriptors, namely, the atmospheric condition, effective root distribution, and root water uptake efficiency dependent on soil water potential that is controlled by soil water availability. These studies further improved and optimized the water uptake model of plant roots.

Scholars have extensively researched the distribution of root system and water uptake and established the water uptake models, of oaks (Katul et al., 1997), apple trees (Green & Clothier, 1997, 1999) and almond trees (Vrugt et al., 2001) and so on. In China, the study of water uptake model of root system was mainly concentrated on the establishment of root water uptake model of crops, except the root system distribution and root water uptake model of the apple trees (He et al., 2000; Yao et al., 2004; Gong et al., 2006), other trees have not been researched.

As the most important forest resources in desert regions of Northwest China, Populus euphratica forests are an important ecological screen in northern area of China. They play an irreplaceable role in the maintenance of ecological security. Therefore, to clearly understand the consumption of ground water by Populus euphratica forests, the study of water uptake of the root system in Populus euphratica trees in the desert riparian forest has an important and practical significance. The aims of this study are as follows: 1) To establish the fine root distribution pattern of Populus euphratica in desert riparian forest in the extreme arid region; 2) to ascertain the main parameters affecting the water uptake of root system, the function of water potential influence, the distribution function of root-length density and the amount of transpiration; 3) to set up the root water uptake model of Populus euphratica in desert riparian forest in the extreme arid region; 4) to validate the water-uptake model.

MATERIALS AND METHODS

Experimental Site and Plant Material

The experiment was conducted in the Populus euphratica Forest Reserve (101°10′E 41°59′N, 920.46 m elev.) in the Ejina oasis in the lower Heihe basin in northwest China. The site is one of the extreme arid regions in China. Annual rainfall in the region is less than 50 mm, of which 84% falls during the rainy season (May-September) and evaporation is larger than 3700 mm. The average yearly air temperature is about 8.2 °C. Prevailing wind directions are northwest in winter and spring, and southwest to south in summer and autumn. The yearly average wind speed is about 3.4 to
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