Chapter 13
Simulation of Wetted Zones Under Subsurface Drip Irrigation

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ABSTRACT

Irrigation plays an important role in solving the food security problem. Hence, subsurface drip irrigation (SDI) becomes more and more widely used. Its expansion requires studies to determine the parameters of wetted zones for various conditions. We propose to study the process of wetted zones formation in soil using mathematical modeling by solving the initial-boundary value problem for moisture transport equation in vadose zone of soil. Using the proposed approach, the determination of wetted zones under SDI was performed for Ukrainian soils of different texture. Based on the results of mathematical modeling, the main parameters of wetted zones were determined. Empirical dependencies of wetted zone parameters on the structural parameters of SDI systems and pre-irrigation threshold were also established. With a decrease in the pre-irrigation threshold, all wetted zone parameters increased

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and the process of zone's formation for sands, sandy loams, and light loams can be described by linear dependencies, while for medium loams, heavy loams, and clays they have a polynomial form.

INTRODUCTION

The environmental and economic sustainability of agriculture is now mainly studied in the content of the so-called Water-Energy-Food (WEF) nexus (see, e.g., [Kuzmych and Yakymchuk, 2022]). This approach makes stress on multiple mutual influences of the issues of water, energy, and food securities and also the soil, water, and land ecosystems. Aiming at long-term economic, social, and environmental goal, the usage of the WEF nexus approach is, nevertheless, in the end bounded, in some aspects, to technical and technological solutions. It is specifically pronounces in the case of interconnections between water and food securities that rely on the decisions made in the field of irrigation and drainage.

In the case of Ukraine, these issues were brought up in the Strategy of Irrigation and Drainage in Ukraine until 2030, which was developed with the participation of the specialists of the Institute of Water Problems and Land Reclamation of NAASU and approved by the Cabinet of Ministers of Ukraine on August 14, 2019. It provides for the introduction of more than 1,180,000 ha of additional irrigated areas. While solving this problem the focus should be made on the application of the most novel methods and technologies of irrigation, which, thanks to the optimization of irrigation water consumption, ensure the economy of agricultural resources, energy conservation, and reduction of ecological burden on agrophytocenoses. Subsurface drip irrigation (SDI) most fully meets these requirements.

Under subsurface drip irrigation, water and nutrients are in many cases used much more efficiently than under other types of irrigation. This allows more complete use of the genetic potential of agricultural crops. Although this irrigation method is more efficient than traditional drip irrigation, it is mainly used on more valuable fruit crops due to higher capital costs. But in connection with the growing shortage of water resources and the constant increase in the cost of irrigation water, particularly due to the military aggression of the Russian Federation, the use of subsurface drip irrigation in the cultivation of other (vegetable, technical, etc.) crops will constantly increase.

The limited use of SDI systems is also explained by the lack of general theory and methods of mathematical calculation of systems' design parameters. Therefore, the development of a methodology for substantiating the structural parameters of subsurface drip irrigation systems and water supply regimes that ensure the optimal