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Modeling water flow and nitrate dynamics in a plastic mulch vegetable cultivation system using HYDRUS-2D

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Growing vegetables commercially requires intensive management and involves high irrigation demands and input of agrochemicals. Plastic mulch application in combination with drip irrigation is a common agricultural management technique practiced due to variety of benefits to the crop, mostly vegetable biomass production. However, the use of these techniques can result in various impacts on water and nutrient distribution in underlying soil and consequently affect nutrient leaching towards groundwater resources. The aim of this work is to estimate the effect of plastic mulch cover in combination with drip irrigation on water and nitrate dynamics in soil using HYDRUS-2D model. The field site was located in Croatian costal karst area on a Gleysol (WRB). The experiment was designed according to the split-plot design in three repetitions and was divided into plots with plastic mulch cover (MULCH) and control plots with bare soil (CONT). Each of these plots received applications of three levels of nitrogen fertilizer: 70, 140, and 210 kg per ha. All plots were equipped with drip irrigation and cropped with bell pepper (Capsicum annuum L. cv. Bianca F1). Lysimeters were installed at 90 cm depth in all plots and were used for monitoring the water and nitrate outflow. HYDRUS-2D was used for modeling the water and nitrogen outflow in the MULCH and CONT plots, implementing the proper boundary conditions. HYDRUS-2D simulated results showed good fitting to the field site observed data in both cumulative water and nitrate outflow, with high level of agreement. Water flow simulations produced model efficiency of 0.84 for CONT and 0.56 for MULCH plots, while nitrate simulations showed model efficiency ranging from 0.67 to 0.83 and from 0.70 to 0.93, respectively. Additional simulations were performed with the absence of the lysimeter, revealing faster transport of nitrates below drip line in the CONT plots, mostly because of the increased surface area subjected to precipitation/irrigation due the absence of soil cover. Contrary, in the MULCH plots most of the nitrate applied was still left in the upper soil layer at the end of simulations. Numerical modeling revealed a large influence of plastic mulch cover on water and nutrient outflow and distribution in soil. Results suggest that under this management practice the nitrogen amounts applied via fertigation can be lowered and optimized (higher application frequencies) to reduce possible negative influence of the nitrogen based fertilizer such as leaching of nitrates to groundwater.

Keywords: Plastic mulch cover; Vegetable cultivation; Water flow; Nitrate dynamics; HYDRUS-2D