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Validation and application of a two-dimensional model to simulate soil salt transport under mulched drip irrigation

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Water shortage and soil salinization increasingly become the main constraints for sustainable development of agriculture in Southern Xinjiang, China. Mulched drip irrigation, as a high-efficient water-saving irrigation method, has been widely applied in Southern Xinjiang for cotton production. In order to analyze the reasonability of describing the three-dimensional soil water and salt transport processes under mulched drip irrigation with a relatively simple two-dimensional model, a field experiment was conducted from 2007 to 2015 at Aksu of Southern Xinjiang, and soil water and salt transport processes were simulated through the three-dimensional and two-dimensional models based on COMSOL. Obvious differences were found between three-dimensional and two-dimensional simulations for soil water flow within the early 12 h of irrigation event and for soil salt transport in the area within 15 cm away from drip tubes during the whole irrigation event. The soil water and salt contents simulated by the two-dimensional model, however, agreed well with the mean values between two adjacent emitters simulated by the three-dimensional model, and also coincided with the measurements as corresponding RMSE less than 0.037 cm^3 cm^{-3} and 1.80 g kg^{-1}, indicating that the two-dimensional model was reliable for field irrigation management. Subsequently, the two-dimensional model was applied to simulate the dynamics of soil salinity for five numerical situations and for a widely adopted irrigation pattern in Southern Xinjiang (about 350 mm through mulched drip irrigation during growing season of cotton and total 400 mm through flooding irrigations before sowing and after harvesting). The simulation results indicated that the contribution of transpiration to salt accumulation in root layer was about 75% under mulched drip irrigation. Moreover, flooding irrigations before sowing and after harvesting were of great importance for salt leaching of arable layer, especially in bare strip where drip irrigation water hardly reached, and thus providing suitable root zone environment for cotton. Nevertheless, flooding irrigation should be further optimized to enhance water use efficiency.