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Modeling soil-water dynamics for sustainable Argan reforestation using Subsurface Water Retention Technology (SWRT) and HYDRUS-2D in southwest Morocco

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Land degradation is a major concern in the Mediterranean region. In southwest Morocco, the Argan agroforestry system, part of the UNESCO Biosphere Reserve network, is the primary income source for rural communities. However, it faces growing threats from increased drought, soil erosion, and overgrazing by goats and camels. To face these challenges, combining modeling tools and new water-saving technologies is a promising approach for promoting sustainable argan production. In this study, we used the HYDRUS-2D model to assess the effectiveness of subsurface water retention technology (SWRT) in improving the survival of argan seedlings transplanted for reforestation on coarse-textured soils. A total of 460 argan tree seedlings were transplanted in the Essaouira Living Lab of the PRIMA SALAM-MED Project. Biodegradable SWRT membranes were applied to 50% of the seedlings, while the remaining 50% were left without SWRT. Ground-based data on soil properties, irrigation, climate, and soil moisture were collected from the study site and used to set up and run the model. The adopted methodology involved multisite calibration of soil water content at three depths (10 cm, 20 cm, and 40 cm) to estimate water losses across 10 sites, comprising five sites with SWRT and five sites without SWRT. The results obtained showed that the HYDRUS-2D model correctly simulated the observed soil water content in nearly all sites with and without SWRT. Furthermore, the highest reduction rates in simulated water losses were observed in soil profiles with SWRT compared to those without SWRT which exhibited higher loss rates. Overall, our findings highlight that SWRT is an effective solution for enhancing water-use efficiency and improving root zone water storage, promoting argan tree growth in the Essaouira region, particularly in soils with high infiltration capacity and permeability. Implementing SWRT can also contribute to sustainable land management practices and support local communities by fostering resilient agroforestry systems and securing their primary income source.

Keywords: Mediterranean region; Forest degradation; Argan tree; Land management; SWRT; HYDRUS-2D.

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