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Simulating Soil Salinity and Determining Proper Irrigation Scheduling in Pistachio Orchards of Qazvin(Iran)

موسسه تحقیقات خاک و آب

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Introduction

Proper irrigation management is crucial for preventing salt accumulation and achieving optimal performance in agricultural and orchard settings, considering limited water resources and varying water quality. In Qazvin, Iran, there is a lack of comprehensive irrigation management specifically for pistachio orchards using the drip-surface irrigation method. This presents an opportunity to explore different irrigation strategies, such as interval and depth variations, to improve performance and reduce water consumption. Identifying pistachio orchards utilizing surface drip irrigation is essential for providing tailored management solutions to enhance water efficiency and increase yield. Despite their resilience to drought, pistachio trees require careful consideration of factors like soil texture, evapotranspiration, water and soil salinity, irrigation method, tree age, and available water. Various irrigation methods, including surface and subsurface drip irrigation, are employed for pistachio cultivation. Water salinity poses a significant challenge in dry and salty regions, impacting growth, yield, and product quality. However, studies suggest that proper irrigation management can promote successful pistachio growth and good yields even in saline conditions (Bagheri et al., 2019). The two-dimensional Hydrus model, which incorporates the Richards equation and accounts for plant root water absorption, offers accurate evaluation of soil hydraulic properties and simulation of water and solute movement under different boundary conditions, irrigation strategies, and plant types (Jiang et al., 2023; Devkota et al., 2022).

Methodology

The number of three orchards in Qazvin province were selected in order to identify the irrigation management of pistachio orchards (with a greater concentration of pistachio orchards and surface drip irrigation system.

- **Selection of Orchards**: Three pistachio orchards in Qazvin province were chosen based on their utilization of surface drip irrigation.
- Salinity Measurements: Salinity variations were measured at two times and three depths (0-30 cm, 30-60 cm, and 60-90 cm) in the selected orchards.
- **Meteorological Data**: Three years of meteorological data (2018-2020) from Qazvin synoptic weather station were used to determine standard evapotranspiration.
- **Orchard Characteristics:** Tree spacing was 2-3 meters, row spacing was 6-7 meters, and average yield ranged from 1 to 1.5 tons per hectare. Drippers had a flow rate of 8 litre per hour, and irrigation cycle was 25-30 days.
- **Soil Texture:** Majority of orchards had loam-clay to loam soil texture.

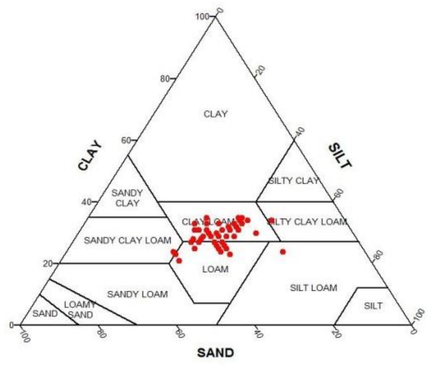

Figure 1: Soil texture of the orchards

- **Water Quality Analysis**: Irrigation water quality was assessed and found suitable for pistachio cultivation.

Table 1: Irrigation Water Quality of Orchards

Specification	pH -	HCO3 (mg/l)	Na (mg/l)	Ca (mg/l)	Mg (mg/l)	EC (dS/m)
No 1	7.7	176	410	78	45	2.5
No 2	7.9	204	385	64	57	2.5
No 3	7.8	240	370	75	30	2.2

- **Model Calibration and Validation**: Hydrus 2D was utilized. The measured data of the first round were used for calibration and the data of the second round were used for validating the model.
- **Scenarios**:

•To: The usual conditions of orchard irrigation management (irrigation cycle 30 day with irrigation time of 6 hour, To);

✓ T1: Irrigation cycle 20 days with irrigation timing 6 hours;

✓ T2: Irrigation cycle 15 days with Irrigation timing 6 hour;

✓ T3: Irrigation cycles of 15 days with irrigation duration of 8 hour.

Results and Discussion

•In scenario T2 and T3, the yield value increased about 1.7 and 1.9 t/h respectively compared to the usual conditions.

• The soil salinity values that are simulated with the two-dimensional Hydrus model have a high relative affinity and agreement with the measured values (Normalized root mean square error of about 20%, NRMSE). This indicates the accuracy of the model in predicting soil salinity.

•A longer irrigation cycle of 25 to 30 days with shorter irrigation duration resulted in most of the soil moisture in the root development zone being within the wilting point range. To improve performance and increase the depth of wetted soil, it is recommended to reduce the irrigation cycle to approximately 15 days and increase the irrigation duration to 8 hours.

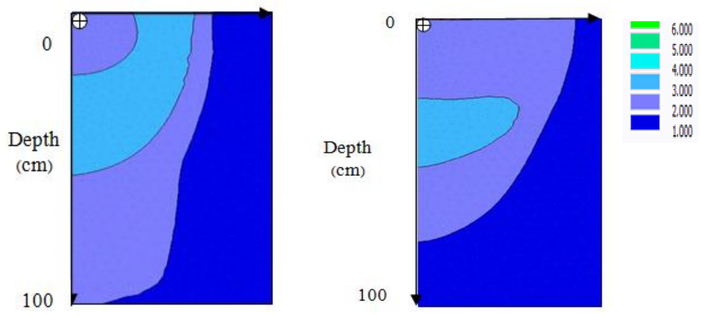

Figure 2: The Typical Soil Salinity Variation with Depth

Conclusions

• Accuracy of the Hydrus Model: The two-dimensional Hydrus model demonstrated a high level of agreement between simulated and measured soil salinity values, with a normalized root mean square error (NRMSE) of approximately 20%. This indicates the model's reliability in predicting soil salinity levels.

• Impact of Irrigation Cycle and Duration: A longer irrigation cycle of 25 to 30 days with shorter irrigation durations resulted in a significant portion of the soil moisture in the root development zone falling within the moisture range of the wilting point. This created severe moisture stress, leading to yield reduction.

• Consideration of Performance and Root Development: To optimize performance and increase the depth of wetted soil, it is recommended to adjust the irrigation cycle and duration. Specifically, reducing the irrigation cycle to approximately 15 days and increasing the irrigation duration to 8 hours is suggested.

In summary, the study highlights the importance of proper irrigation management to mitigate soil salinity and optimize pistachio yield.

References

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