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Research Article
Salinity Effect on the Crop Height, Root Depth and Leaf Index Area of Tomato Crop in Tunisia

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Abstract

Background and Objective: In arid and semi-arid regions, the extension of irrigated areas has led to the use of saline water for irrigation. The consequences of irrigation with saline water are harmful for soil and crops. The objective is to assess the effect of the irrigation with saline water on the main crop parameters. **Materials and Methods:** In this study, two experiments were conducted in a semi-arid region in Tunisia in field conditions and in pots. A tomato crop was irrigated with three qualities of saline water: 0, 3.5 and 7 ds m^{-1}. In the field conditions, the estimation of crop water requirements was carried out by the CROPWAT software with 10 years of data and for the pots experiment by monitoring the soil water content. During the crop cycle, crop height, root depth and leaf index area were measured regularly. **Results:** The obtained results show that the effect of irrigation with saline water is significant for both parameters crop height and root depth in the case of the field experiment whereas it is not significant for leaf area index and for all the measured crop parameters in the case of the pot experiment. **Conclusion:** The use of saline water for tomato crop irrigation is possible with adequate agricultural practices.

Key words: Tomato crop, irrigation, saline water, loamy-clay soil, Tunisia

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The aridity of the climate increases the evaporation rate in the soil and consequently favors the concentration of salts in the soil. The increase of soil salinity destroys the soil structure, reduces infiltration and crop yields. In Tunisia, an arid and semi-arid country, the use of salt water is an obligation with the lack of adequate quality water resources. Tomato crop is a strategic in Tunisia and some varieties are quite tolerant to salinity. The effect of salinity on the height of tomato plants was studied by Chaali *et al.*[1], Cuartero and Fernandez-Munoz[2] and Takase *et al.*[3] where they showed that the increase of soil salinity affects the development of the plant and the height decreases. This result is also valid for the root depth case[4]. The effect of salinity on the leaf area index is explained by the fact that the decrease in vegetative growth of the tomato plant affects the leaf surface[5-7].

Numerical models are powerful tools for the accurate assessment of salinization risks of soils and crops. Simulation of crop yields requires input data and morphological parameters: plant height and root depth and leaf area index. These parameters are related to actual evapotranspiration and relative yields can be estimated form the potential yields. The Hydrus-1D[8] model in its most recent version allows the estimation of the actual evapotranspiration and the potential evapotranspiration and determines as an indirect result[9] the relative yield. The previously mentioned parameters are necessary for its calculus.

In the context of semi-arid region like Tunisia, the values of the crop height, the root depth and the LAI were characterized by Panuccio *et al.*[10], Klay *et al.*[11] and Ahmed *et al.*[12]. However, the effect of the irrigation water salinity on the previous parameters was not studied enough. The objectives of this paper is to compare the effect of irrigation with saline water on a tomato crop cultivated in field conditions and in pots and thus characterize the parameters necessary for a possible modeling.

MATERIALS AND METHODS

Crop experiments: The selected land parcel belongs to the city of Ariana (36°50′40.791″ N, 10°11′13.795″ E) in Tunisia, a semi-arid Mediterranean region. The soil is loamy-clay. A tomato crop (*Rio Grande*) was cultivated in two experiments: In field conditions with a planting density of 0.175 m^2. The plantation was carried out on the April, 17th 2018 and the harvest on the August, 3rd 2018.

In pots filled with the same soil (dimensions 30 cm as diameter and 50 cm of height). The date of planting was March, 16th 2018 and that of the harvest was Jun, 10th 2018.

Irrigation management : For the field experiment, crop water requirements were estimated from 10-year climate data (2007-2017). Mean values were used to estimate reference evapotranspiration by the penman-monteith formulas (FAO-56). For the calculation of actual evapotranspiration, the crop coefficient values for the three crop stages were taken from the values proposed by Allen *et al.*[13]. These values are as follows: Kc = 0.6 (initial stage), Kc = 1.15 (medium stage) and Kc = 0.8 (final stage). To establish the irrigation schedule, the CROPWAT 8.0 software[14] was used. The water requirements of the tomato crop are around 720 mm.

For the pot experiment, the irrigation management was based on monitoring the soil moisture content by a BIOS probe, which allows the simultaneous measurement of the moisture content and the temperature. The field capacity in the case of soil in the pots is 34% and represents the optimum value where the plant can absorb the water without returning to a state of stress. Irrigation is done manually until the soil water content reaches the value of the field capacity. The quantities of water added were around 350 mm.

Irrigation water has been brought to plants with different qualities:

- Water with a salinity of 0 ds m^{-1}
- Water with a salinity of 3.5 ds m^{-1}
- Water with a salinity of 7 ds m^{-1}

Measurement of the crop parameters: Crop height and root depth were measured every 10 days from the planting date to the end of the cycle for the experiment. The leaf area was measured with the software Mesurim pro with an interval of 10 days. Each treatment was repeated five times, a torn leaf is pulled off and then scanned. The resulting image is processed by the software Mesurim pro, which allows giving the leaf area index.

Statistical evaluation: The statistical evaluation was done by STATISTICA software. The one-way ANOVA was performed using the F-test at a significance level of 5%.

RESULTS AND DISCUSSION

The measurements of plant height, root depth and LAI parameters were used to study the effect of the irrigation with saline water on the tomato crop in the case of field conditions and in the pots.

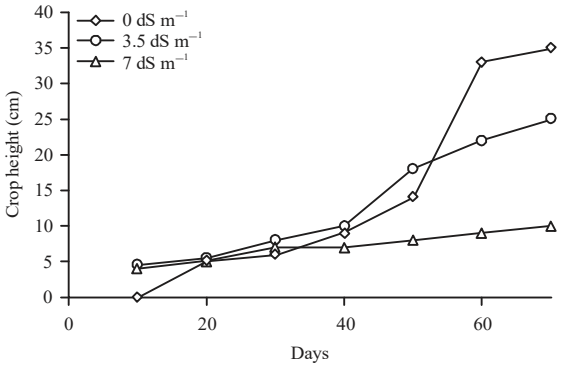

Fig. 1: Evolution of the tomato crop eight in the field conditions

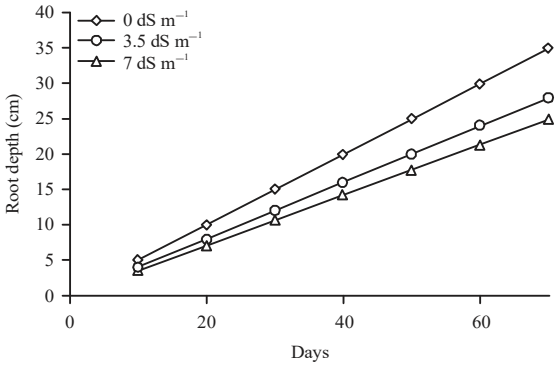

Fig. 3: Evolution of the tomato root depth in the field conditions

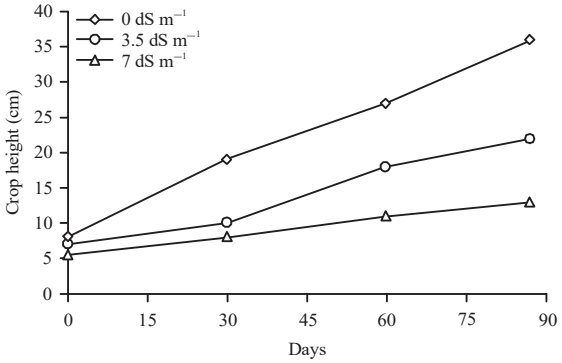

Fig. 2: Evolution of the tomato crop eight in the pots

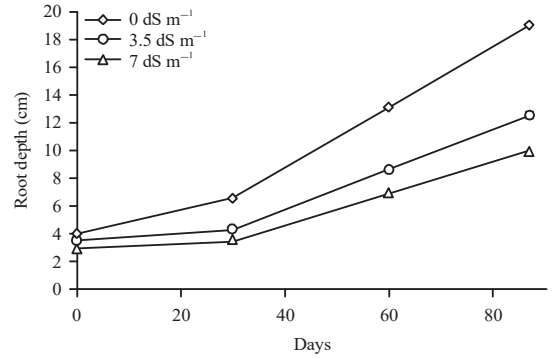

Fig. 4: Evolution of the tomato root depth in the pots

Salinity effect on the crop height: According to Fig. 1 and 2, the maximum length of the plant did not exceed 40 cm for both pots and field experiments. In the latter, the growth of the plant was exponential from the 30th day, whereas, the evolution of the length of the plant was more progressive in the case of the pot experiment. The effect of irrigation with saline water was very clear and it was highlighted by a decrease in the size of the plants according to the salinity. A saline water of 7 dS m^{-1} blocked the growth of the plant, whose size only increased by 15 cm after 87 days of irrigation.

Salinity effect on the root depth: In Fig. 3 and 4, the root depth varied between 8 and 15 cm for the pots and between 22 and 40 cm for the field conditions. It decreased depending on the quality of irrigation water.

Salinity effect on the leaf index area: The Leaf Area Index (LAI) was more important for tomato plants grown in the field (Fig. 5 and 6). The LAI values also decreased with increasing salinity of irrigation water. This decrease was visible in the late stages of growth of the crop (after 30 days) whereas it was less visible in the 1st day of the plant cycle. The effect of salinity was moderate in this stage.

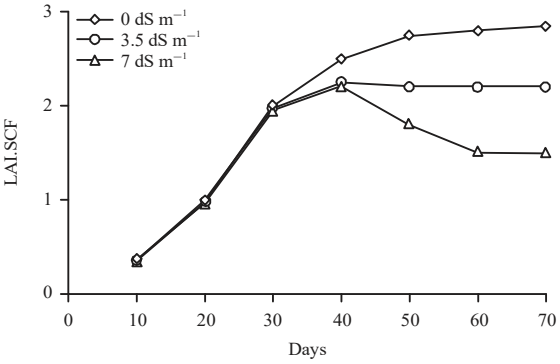

Fig. 5: Evolution of the LAI in the field conditions

Significance of the salinity effect: The one-way ANOVA performed to study the significance of the effect of saline water on Tomato crop parameters shows:

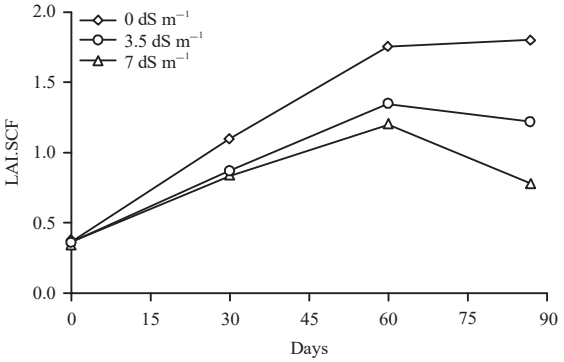

Fig. 6: Evolution of the LAI depth in the pots

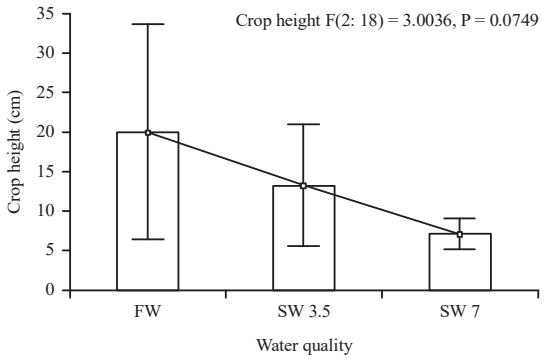

Fig. 7: Effect of the water quality on the crop height of the field experiment

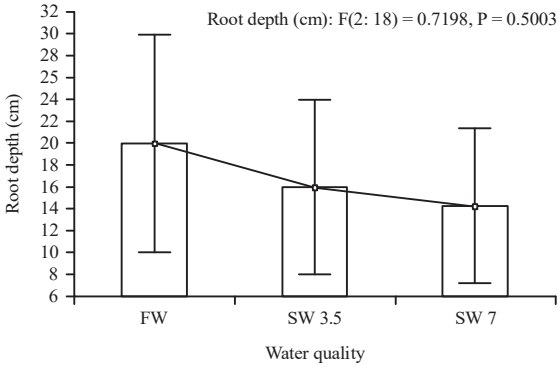

Fig. 8: Effect of the water quality on the root depth of the field experiment

- **In the case of field experiment:** The $p<0.05$ for the crop height and the root depth. The effect of water salinity was significant (Fig. 7 and 8). For the case of the LAI $p>0.05$, the effect of the irrigation with saline water was not significant (Fig. 9)
- **In the case of the pots experiment:** The $p>0.05$ for the all the studied parameters (Fig. 10-12). The increase of the salinity in the irrigation water was not significant on the crop height, the root depth and the LAI

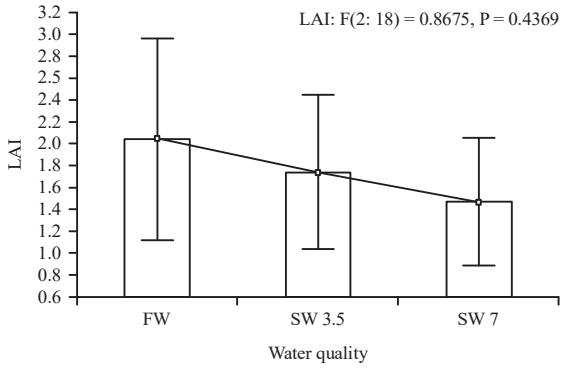

Fig. 9: Effect of the water quality on LAI of the field experiment

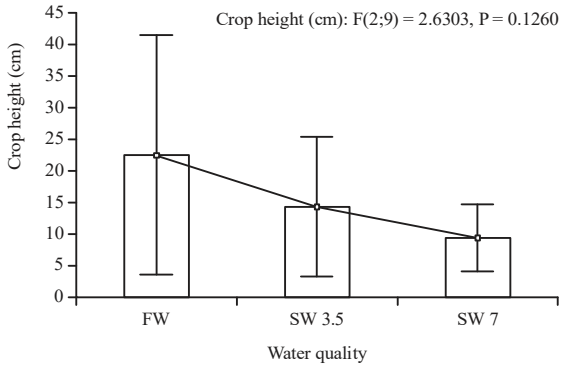

Fig. 10: Effect of the water quality on the crop height of pots

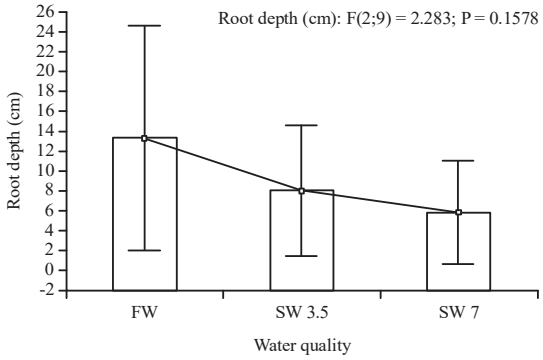

Fig. 11: Effect of the water quality on the root depth of the pots

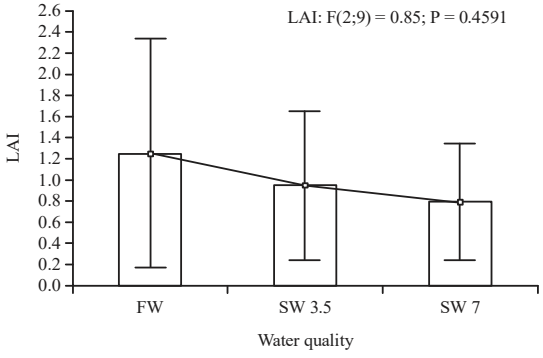

Fig. 12: Effect of the water quality on the LAI of the pots

DISCUSSION

The accumulation of salts in the root zone has the effect of increasing the osmotic potential which prevents the roots from absorbing the water and consequently the decrease of the growth of the plants.

This effect was observed at the level of two parameters, crop height and root depth in the case of field conditions as in the study of Najla *et al.*[15], Shouse *et al.*[16] and Cai *et al.*[17]. In the case of LAI, the effect of salinity is not significant based on ANOVA analysis by comparing the average values of each parameter[18,19]. ANOVA did not give any significant result for the pots experiments[20,21]. The success of the irrigation strategy by monitoring the soil moisture content is the cause. The doses of water brought into each pot eliminated salt stress.

The use of the measured crop parameters can serve as input for an integrated modelling of water flow and solute transport in the soils in order to study the effect of soil salinity on crops yields.

CONCLUSION

In this study, the effect of irrigation with salt water was studied for a tomato crop in the case of two experiments, one in field conditions and the other in pots. The salinity effect of the irrigation water is significant for the morphological parameters of the crop whereas it is not significant in the case of the LAI. Choosing a good irrigation strategy is the key to proper salinity management at the plot scale.

SIGNIFICANCE STATEMENT

This study discover the effect of the irrigation with saline water on the crop height, root depth and the LAI of tomato crop in semi-arid region of Tunisie. This study will help the researcher to uncover the critical areas of crop modelling associated with the mentioned parameters.

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