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Research Article

Effect of Different Drip Line Depths on Water Use of Eggplant under the Semi Arid Climate of Central Tunisia

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Abstract

Despite Several researches have been carried out on subsurface drip irrigation (SDI), local information on the response of eggplant production and water dynamics with SDI still very limited in Tunisia. However, the interaction of climate, soils, and crop production presents unique arrangement requiring local knowledge to improve the productivity. The main objective of this work was to evaluate and compare the effect of traditional and subsurface drip irrigation in semi-arid regions on soil water contents, Yield and water use efficiency. Experiments were conducted at the High Agronomic Institute of Sousse-Tunisia, for eggplant. Results showed that at increasing drip line depth, water content resulted higher, as a result of minor evaporative losses. In addition, results showed that a buried dripline at 0.20 m allowed an improvement of yield with about 14%, compared to the traditional drip irrigation. Moreover, it was concluded that WUE varied little with drip line depth, Whereas IWUE resulted more sensible to the drip line depth. In general, it was demonstrated that when increasing the depth of the drip lateral, IWUE increased.

Keywords: Subsurface Drip Irrigation; Drip Lateral Depth; Potato; Irrigation Water Use Efficiency; Water Scarcity Minimum

Introduction

Under the Mediterranean region, the climate is characterized by the scarcity and the irregularity of precipitations [1]. In some places of central and southern Tunisia, average rainfall could reach values less than 350 mm per year. Future projections will be more and more scarce [2]. Therefore, irrigation is becoming compulsory to intensify the production. However, good irrigation management is crucial in optimizing water efficiency. Subsurface drip irrigation (SDI) system, by providing directly water inside the ground instead of on the soil surface, may improve irrigation water use efficiency [3]. This improvement is mainly linked a reduction of soil water evaporation losses since the irrigation wet bulb does not appear on the top surface. Camp [4] after reviewing results of previous works concluded that crop yields for subsurface drip systems were the highest compared to other irrigation systems in all cases, including different crops, soils, and cropping conditions. However, for those systems, the distribution of soil wetted areas is quietly affected by the soil proprieties and irrigation management. One of the most commonly discussed features of SDI system is installation depth [5]. when designing subsurface drip irrigation systems, dimensions of the wetted bulb and the distribution of soil water content within the bulb are key factors for determining installation depth and spacing of emitters [6]. While deep lateral depth may reduce soil evaporation, it can increase water losses with deep percolation. Since crops under such conditions could be subject to water deficit [7]. Despite the importance of that parameters, Lateral depths have been poorly studied as a treatment variable; hence, no information are available in terms of the interaction between irrigation water use efficiency and drip lateral. Therefore, the objectives of this study were to evaluate the effects of different drip irrigation lateral depths on evapotranspiration, yield and water use efficiency of eggplant under the semi arid environment of Tunisia.

Materials and Methods

Experiments lasted for three months from April to June 2007, at High Institute of agronomy in Chott Meriem, central Tunisia, Sousse (Longitude 10.5604 ∘ E, Latitude 35.9130 ∘ N, Altitude 15 m a.s.l.). In order to test dripline depth on water use efficiency of eggplants (*Solanum melongena L.*), the experimental field was splitted into three subplots of 25 m large and 40 m long. Distances between eggplants (*Solanum melongena L.*) were equal to 0.3 m between the rows and 0.30 m along the rows of. The depth of the drip lateral on the first sub-plot was 0 m, traditional drip irrigation (TDI), whereas in the second plot was 0.10 m (SDI20) and the third one 0.2m (SDI20).

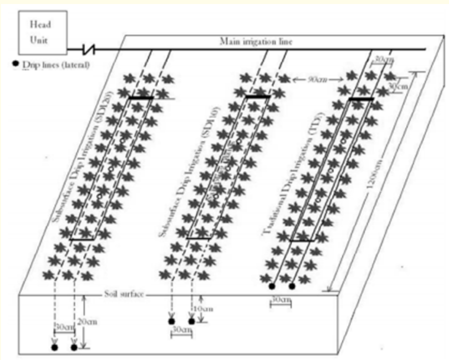

Figure 1: Eggplant spacing and drip line placement in the experiment.

Emitters allowed to deliver a flow rate of 2.0 l h^{-1} at a nominal pressure of 100 kPa. A climatic station situated at distance 300 m from the field experiments provided meteorological standard variables (air temperature, humidity, solar radiation, precipitation and wind speed at 2 m), necessary for the computation of Reference evapotranspiration based on the modified FAO Penman-Monteith equation [8]. FAO "single crop approach" was considered to calculate maximum evapotranspiration. The spatial and temporal evolution of soil water content was followed by TDR probes at depths of 15 cm, 30 cm and 45 cm and at distances of 0 cm, 5 cm, 10 cm and 15 cm, perpendicularly to plant row. Irrigation water was provided, considering the distribution of precipitations, every week to ten days at the starting of the vegetative growth cycle (March and April) and weekly during the crop full development stage and harvesting (May and June). In total fifteen irrigations of 1h were provided for the whole season.

Results and Discussion

Climate condition

Figure 2 shows dynamic of reference evapotranspiration during the growth cycle. Daily values of ET0 increased from 2.0 mm d−1 at the end of February to about 4.0 mm d^{-1}, at the end of June. Precipitations events were absent after the end of April, except for two insignificant events in May. Since, Irrigation was more frequent during that period in order to overpass a period of maximum environmental demand.

Figure 2: Temporal evolution of reference evapotranspiration ET0, and Precipitations, P.

Figure 3 shows values of daily maximum crop transpiration, Tm, and soil evaporation, Em, calculated based on Penman Monteith ET0 values and a single crop coefficient approach. As can be observed, Tm tended to increase from 0.4 mm d^{-1} to about 4.0 mm d^{-1} during the growing season, from mid of March to the end of June. During the full development stage, daily Tm varied between 3 and 4 mm d^{-1}. According to Ep, values were between 0.5 and 1.0 mm d^{-1} during the initial stage and decreased to reach values, equal to 0.1 mm d^{-1}, after mid April, as a result of reduction of rainfall events.

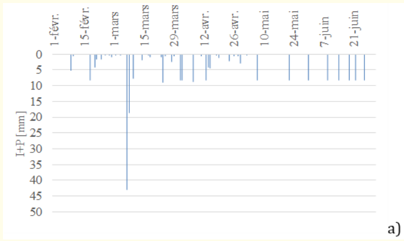

Figure 3: (a) Irrigation and Precipitation distribution, (b) daily values of potential evaporation, Ep, and transpiration, Tp, during the growing period.

Soil water content

The obtained measurements indicated that the study period can be divided into two intervals before and after May 02. For the first period, soil water content varied on the same range. Then, when precipitation became scarce and the climate demand was higher, the effect of the different treatment on soil water content resulted more perceptible. Hence, Soil water content from treatment SDI 20 was always greater than that from TDI and SDI 10 treatments. The period after May 02 coincides by a period of frequent irrigation. In addition, it is also revealed that, soil water content increased in response to irrigation and precipitation and decreased between two consecutive irrigations without significant rainfall. This decrease became faster as the climate warmed up and the eggplant reached an advanced vegetative stage. Moreover, the difference in soil water content between TDI and SDI treatments was higher for an advanced vegetative stage. This could be attributed to the more developed active roots in a zone of maximum humidity in a case of SDI, while for TDI root were concentrated on top soil in a soil layer of maximum evaporation. Indeed, A previous research of Sakellariou., *et al*. [9] demonstrated that SDI allowed a water saving of 16.6% for buried irrigation systems at a depth of 0.45 m. In the same direction, Douh and Boujelben [1] found that SDI irrigation determined higher water contents as compared to TDI.

Figure 4: Temporal evolution of average soil water content in the root zone.

Yield and Irrigation water use efficiency

Final total yields from nine plants from each treatment revealed that the difference was significant ($P < 0.05$) and allowed to classify them into two groups (Figure 5). In fact, the highest yield was recorded for the buried irrigation system at 0.20 and 0.10 m with average values respectively equal to 28 ± 4.5 and 23 ± 5 t/ha, Whereas the lowest yield was for the traditional subsurface drip irrigation (20 ± 2.1 t/ha). Hence, a buried dripline at 0.20 m allowed an improvement of yield with about 14%. This can be explained by the greatest soil water availability within the root zone observed under SDI 20, especially during the drought period (Figure 3). This result agrees with those of Singh and Rajput [10] who found a subsurface drip irrigation system allowed to improve from several horticultural crop such as cucumber, tomato and okra. In contrast to that, Enciso., *et al*. [11] who noted that underground drip irrigation had no significant effect on soil moisture content and yields. Moreover, the regression line between yield and drip line depth allowed traducing this interaction with a high correlation coefficient (R^2=0.98). Therefore, this function could be assumed when choosing the depth of the irrigation system.

Figure 5: Crop Yield as response to the depth of the drip lateral.

Figure 6 shows the effect of dripline depth on WUE and IWUE. WUE was obtained as the ratio between final yield and total applied water (irrigation and precipitation), whereas IWUE involved only irrigation water. As can be observed, WUE varied little with drip line depth. This could be assumed to the importance of rainfall, especially during the first period of the growth cycle. As was expected, IWUE was more sensible to the drip line depth. Results showed that when increasing the depth of the drip lateral, IWUE increased. The regression function between IWUE and irrigation system depth revealed a high correlation R^2=0.98). This function depicts that the farmer can profitably irrigate more land, when using the adequate drip lateral depth. Several authors concluded that subsurface drip irrigation allowed improving the efficiency of the irrigation water for numerous crops like turnip, tomato, onion and okra crops [11-13].

Figure 6: Effect of drip lateral depth on water use effecieny (WUE) and irrigation water use efficiency (IWUE).

Conclusion

The main objective of this work was to evaluate and compare the effect of traditional and subsurface drip irrigation in semi-arid regions on soil water contents, Yield and water use effeciency. For subsurface drip irrigation, values of water content resulted constantly higher than it was for the traditional drip irrigation. Moreover, at increasing the depth of the drip line, water content resulted higher, as a result of minor evaporative losses. Results showed that highest yields were recorded for the buried irrigation system at 0.20 and 0.10 m with average values respectively equal to 28 ± 4.5 and 23 ± 5 t/ha, Whereas the lowest yield was for the traditional subsurface drip irrigation (20 ± 2.1 t/ha). Hence, a buried dripline at 0.20 m allowed an improvement of yield with about 14%. Moreover, it was concluded that WUE varied little with drip line depth. This could be assumed to the importance of rainfall, especially during the first period of the growth cycle. However, IWUE was more sensible to the drip line depth. Results showed also that when increasing the depth of the drip lateral, IWUE increased.

Conflict of Interest

Declare if any financial interest or any conflict of interest exists.

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