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Effects of surface and subsurface drip irrigation on agronomic parameters of maize *(Zea mays L.)* under Tunisian climatic condition

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ABSTRACT

This study was carried out to determine the effects of different dripline depths on physiological and agronomic parameters of maize (Zea mays L.) under the Mediterranean climatic conditions in Tunisia. Experimental site was located at conducted at the Higher Institute of Agronomy of Chott Meriem (Longitude 10°38'E, Latitude 35°55'N, altitude 15 m above sea level) on a sandy loam textured soil. Irrigation treatments consisted of four different driplines depths (T0: 0m, T1: 0.05 m, T2: 0.20 m and T3: 0.35 m). The crop was irrigated twice a week by regarding estimated crop water requirements. Dripline depth resulted in significantly different yields. The highest grain yield was obtained in T3 treatment with 1.347 kg m^{-2}, and the lowest yield was found in T1 treatment with 1.007 kg m^{-2}. leaf area, 100-kernel weight and grain yield from T3 were significantly higher than in the other three depths. According to the research results, optimum dripline depht for corn plant was found to be 0.35 m. But, it was no significantly effect on crop water use efficiency. The highest water use efficiency WUE was found in T3 (39.2 kg $ha^{-1}mm^{-1}$) and the lowest one was found in the T1 treatment 0.05 m deep (29.3 kg $ha^{-1}mm^{-1}$). Thus a depth of 0.35 m was recommended for subsurface drip-irrigated corn in the Mediterranean Region under those specific conditions.

Keywords: subsurfae drip irrigation, dripline depth, yield, Zea mays L., water use efficiency.

INRODUCTION

The National Water strategy of Tunisia focuses on water as a prime natural resource, a basic human need and a precious natural asset. It is vital for the achievement of a full potential of Tunisia agricultural sector in order to get food self-sufficiency and security. The demand for water is increasing both in agriculture and in particular in municipal sector at significant rates. It is inevitable and necessary to pay attention to the abnormal consumption of water resources (Najafi, 2002). Field water management practices are the most influential factors affecting crop yield particularly in irrigated agriculture in arid and semi-arid regions (Al-Omran and *al*., 2004).

The pressure of using water in agriculture sector is increasing to create ways to improve water use efficiency and taking a full advantage of available water. Added recent increases in energy prices have many irrigated producers asking how to manage inputs to maximize efficiency of their water resources (Stewar, 2001). Adoption of modern irrigation techniques is needed to be emphasized to increase water use efficiency. Drip irrigation is the most effective way to convey directly water and nutrients to plants and not only save water but also increases yields of vegetable crops (Tiwari et *al*., 1998; Tiwari et *al*., 2003). Phene et *al*. (1991) studied the distribution of roots under sweet corn as a function of drip placement and fertilization treatment. They reported differences between surface and subsurface drip irrigation on sweet corn rooting system in the top 0.45 m. High root length density was observed below 0.30 m in the subsurface drip irrigation than in the surface drip (.Al-Omran and *al.*, 2004).

The agronomic response of the crop to irrigation with SDI is needed to be able to evaluate the economic and technical feasibility of using SDI under local conditions and provide scientifically based practical information to the users on best management practices for SDI-irrigated corn (José et *al*., 2008). The results will also be discussed in the context of other similar work at other locations. The Research supplements a larger body of knowledge. In some cases, existing information about SDI use in other regions and with other crops has been transferable. In other cases, it has not. As in many parts of the world, the interaction of climate, soils, and crop production presents unique arrangements that require local research to adjust the production systems.

This study was conducted at the Higher Institute of Agronomy of Chott Meriem, tunisia. It carried out to determine the effects of different dripline depths on physiological and agronomic parameters of maize (Zea mays L.) under local condition.

MATERIALS AND METHODS

Experimental site: Field studies was carried out during may to july 2010, at the High Agronomic Institute of Chott Mariem-Sousse. (Latitude 35°55N, altitude 15 m). The continental climate of the region was described as semi-arid, with an average annual precipitation of 230 mm and approximate dayly evaporation of 6 mm from a free water surface. The soil is sandy clay with average basic infiltration rate of 45 mm h^{-1}. Bulk density of soil was found to be 1.40 g cm^{-3} for the layer 0-60 cm. The field was precision graded to approximately 1 mm m^{-1} slope. The soil had a sandy-clay texture, an average permeability of 45 mm h^{-1}. The water content of soil at field capacity was 38% for the horizon from 0 to 85 cm and 28% for the horizon from 0.85 to 1.00 m. The maize (*Zea mays*) was seeded with row spacing of 0.80 m and in-row spacing of 0.40 m and the whole planting area is 1000 m^2 (25m*40m).

Experimental design and measurements: The maize crop was irrigated with surface drip irrigation (DI) and subsurface drip irrigation (SDI) during the growing season. Drip tubing (GR type, 0.016 m diameter) with 0.40 m emitter spacing built in, each delivering 4 L h^{-1} at 1bar pressure, was used in DI and SDI treatments (10 drip tubing for each irrigation system). The driplinee depths were 0 m, 0.05 m, 0.20 m and 0.35 m. Irrigation scheduling was on a weekly basis using estimated crop water requirements. Irrigation applications were scheduled two times per week. Irrigation depth for each application was half the weekly water requirements. Weather data were obtained from a weather station located adjacent to the experimental area. Fifteen plants are chosen for each treatment to determine the agronomics' parameters.

Corn production data collected during the growing season included irrigation and precipitation amounts, some agronomics parameters. Corn grain yields and yield components were determined by hand harvesting individual. Data was collected from every single ear but only the plot average data will be reported in this paper. The harvesting and final soil water data were collected at physiological maturity.

Grain moisture content was measured for each plot and yield was adjusted to 150 g kg^{-1}. The yield associated with irrigation (YAI) was calculated as the difference between the yield of the subsurface drip irrigation system for each depth (YSDI) and the yield for the drip irrigation system (YDI) in the same replication.

$$YAI = \frac{YSDI}{YDI}$$

The measurements of the leaf area are achieved with the help of an analogical area meter.

Statistical analysis: Results were examined statistically by using the analysis of variance (ANOVA) procedure from the Statistical Analysis System (SAS 9.1 for Windows; SAS Institute Inc., Cary, NC). PROC GLM. F-Tests were considered significant at the 0.05 level of probability and Fisher's protected least significant difference (LSD) was used to compare treatment means for significant ($p \leq 0.05$) effects.

RESULTS AND DISCUSSION

Plants' growth: Figure 1 showed the effects of different depth driplines on plants' heights. It proved that the irrigation system has a highly significant effect on the plants height growth. Certainly, the highest values are registred on the SDI buried at 0.35 m deep. The averages are of 1.387 m, 1.400 m, 1.497 m and 1.727 m respectively for T0, T1, T2 and T3. Data showed that the interactions between height growth and irrigation systems were highly significant, at 5% level, for maize crop.

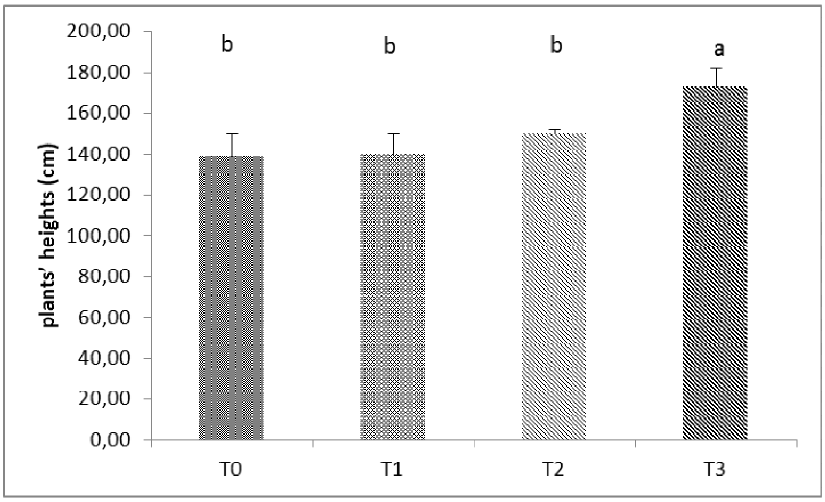

Figure 1: Dripline depths effects on plant's heights

Leaf area: The observation of figure 2 showed a hight significant difference at 5% level between driplines depths and leaf area. The statistical analysis were classified the treatment effect on leaf area into two groups, the first one was to T3 (a), the second had T0, T1 and T2 (b). The highest results had been recorded in the case of the drip irrigation system buried at 0.35 m with an average of 0.3987 m^2/plant, whereas it didn't exceed 0.3533, 0.2425 and 0.3174 m^2/plant respectively in T0, T1 and T2. That result shows the effect of a better water availability of the soil for the crop. These results are similar to those found by Douh and Boujelben (2010) on eggplant crop.

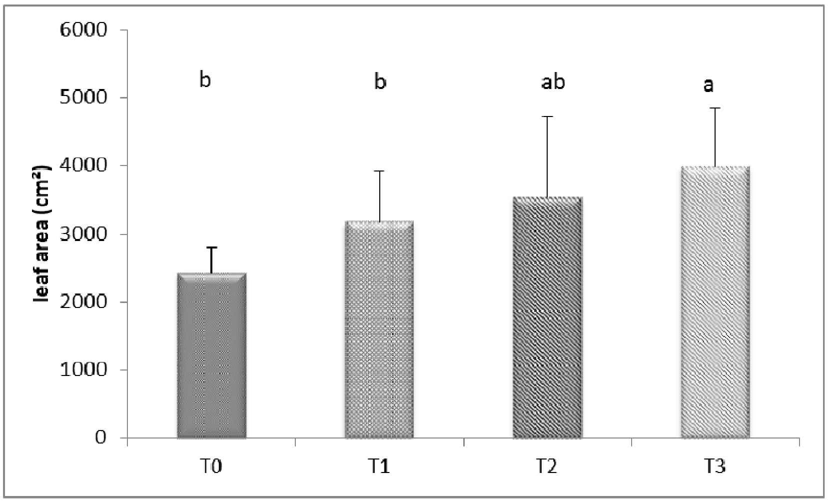

Figure 2: Dripline depths effects on leaf area

Maize grain yield and yield components: Dripline depth had a hight significant effect on maize grain yield (figure 3). The highest grain yield was obtained in T3 treatment with 1.347 kg m^{-2}, and the lowest yield was found in T0 and T1 treatment with 1.040 kg m^{-2} and 10.07 kg m^{-2}. The yield associated with irrigation (YAI) was 1.30, 1.18 and 0.97. The YAI increasing in T2 and T3, showing a positive effect of subsurface irrigation system compared to surface drip irrigation system on crop yield of maize. Economic aspect is put in evidence by the results of comparable production between the two irrigation systems.

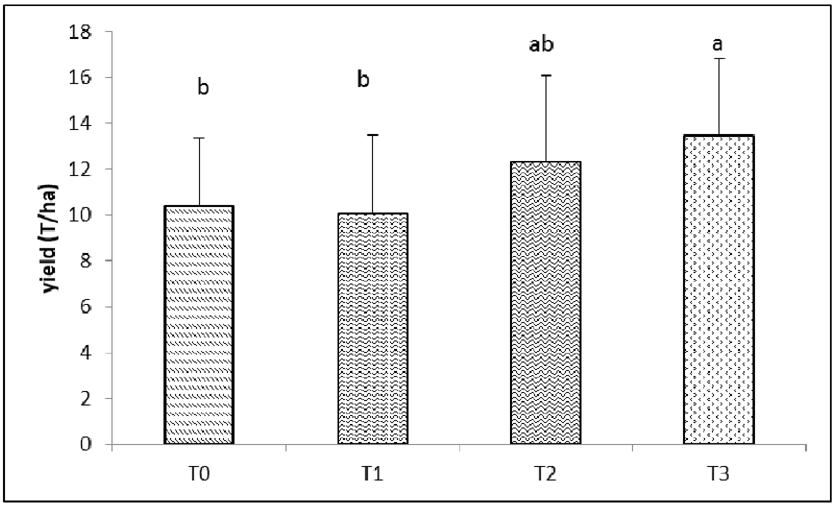

Figure 3: Dripline depths effects on maize grain yield

Douh and Boujelben (2010), proved that SDI buried at 0.20 m allowed an eggplant yield gain of 40% compared to the surface drip irrigation system. Therefore, this is in agreement with the results reported by Lamm and Trooien (2003) and Al-Omran (2004), which proved that differences in squash fruit yield due to irrigation methods were significant and the yield increase is due to subsurface drip irrigation which was about 19.9% over the surface drip irrigation. Also, Water use efficiency was significantly higher with the subsurface drip irrigation compared with the surface system. It appears that subsurface drip irrigation creates more suitable conditions in the root zone area for plant growth and productions. However, in western Kansas, Lamm and Trooien (2005), certified that there were no significant differences in yields attributable to emitter depth.

There were generally significant differences in the yield components where the 0.35 m and 0.20 m deep dripline had greater 100 Kernel Weight than the 0 m and 0.05 m deep (figure 4).

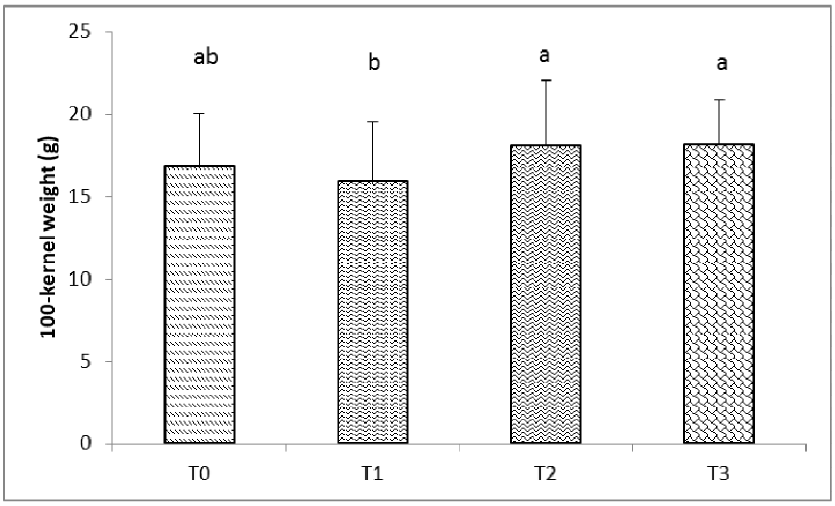

Figure 4: Dripline depths effects on yield components

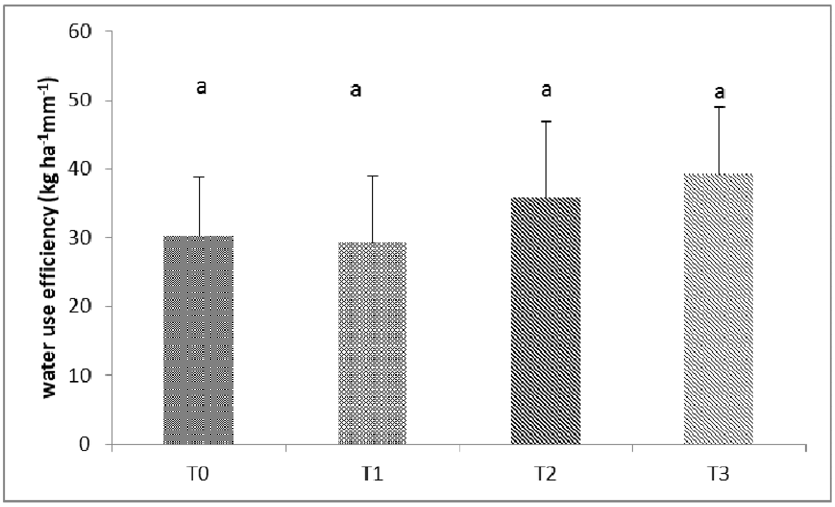

Figure 5: Dripline depths effects on water use efficiency

Water use efficiency (WUE): There was no significant WUE difference between the treatments. the drip irrigation system buried at 0.35 m had the higher WUE (figure 5). WUE had its highest value in the T3 (39.21 kg $ha^{-1}mm^{-1}$) compared to T0, T1 and T2 respectively 30.26 kg $ha^{-1}mm^{-1}$, 29.30 kg $ha^{-1}mm^{-1}$, 35.84 kg $ha^{-1}mm^{-1}$. In fact, it increased about 29.5%, 18.4% in T3 and T2, respectively when compared with T0 treatment. The yield potential of maize was reduced by soil moisuture stress and consequently on the yield and WUE of maize. In addition, subsurface drip irrigation allows uniform delivery of water directly to the plant root zone. This can increase use efficiency over other irrigation methods. These consistently large water productivities obtained in this study are further evidence that drip line depht from 0.20 m to 0.30 m are probably acceptable on this soil type and climate for maize production when the crop is fully irrigated.

The WUE values of this study were lower than some values reported in the literature (Howell et *al.*, 1989). These differences could be explained by the fact that this study was conducted in more arid environment. However, Vories et *al.*(2009) observed a similar value for subsurface drip irrigated corn. Katerji and Hallaire (1984), in their synthesis on indicators of crop water status, demonstrated that soil water status assessed through criteria like soil water content, volume of water supply, humidity, or soil water potential constitute an imperfect parameter to characterise real plant water status, and it leads consequently to variability in WUE. They recommend the use of leaf water potential or pre-dawn leaf water potential in order to identify the actual crop water scheduling and to guide water supply. Under these conditions, yield, crop water use and, in consequence, WUE should present more stable values. Condon and *al.* 2002 added that there is no consistent relationship between plant production and WUE. It may therefore be further concluded that for conditions where high WUE is an advantage because it is a marker for low water use, selection for the preferred plant type can be done by directly selecting for small plant size, small leaf area, or reduced growth duration.

CONCLUSION

This study is to treat the effects of surface and subsurface drip irrigation on the physiological and agronomic parameters of maize (Zea mays L.) under Tunisian climatic condition. It indicated that Dripline depth had a significant difference on the maize crop yield. In fact, the highest grain yield was obtained in T3 treatment with 1.347 kg m^{-2}, and the lowest yield was found in T1 treatment with 1.007 kg m^{-2}. leaf area, 100-kernel weight and grain yield from T3 were significantly higher than in the other three depths. According to the research results, optimum lateral spacing for corn plant was found to be 0.35 m. Dripline depth was no significantly effect on crop water use efficiency. The highest water use efficiency (WUE) was found in T3 (39.2 kg $ha^{-1}mm^{-1}$) and the lowest one was found in the T1 treatment 0.05 m deep (29.3 kg $ha^{-1}mm^{-1}$). Subsurface drip irrigation system buried at 0.35 m allows an uniform soil moisture, minimize evaporative loss and delivery water directly to the plant root zone improving vegetative growth and yield characters. Thus a depth of 0.35 m was recommended for subsurface drip-irrigated corn in the mediterranean region under Tunisian specific conditions.

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