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Effect of Irrigation Systems and Watering Amount on Tomato (*Lycopersicon esculentum*) Production under Semi-arid Conditions

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Abstract

The objective of this study was to quantify the effect of different irrigation systems and water quantities on tomato (*Lycopersion esculentum*) production under dry condition. The study was conducted at south Darfur state (Nyala) at 24^o 53′ E, 12^o 3′ N and 674m above m.s.l. during the winter season 2013/2014 in an area of 0.42 ha. The treatment included two irrigation systems (drip and furrow) and three amounts of irrigation water: (100%, 75% and 50% of tomato ETc). The experiment was organized in spilt plot design and SAS package was sued to achieve the statistical analysis. The measured growth parameters were plant height, stem size and yield ton/ha. Cropwat computer model was used to estimate the tomato evapotranspiration. The results showed that, growth parameters significantly ($P \leq 0.05$) affected by the treatment. Whereas, drip irrigation system gave the highest values of tomato growth parameters and yield (23 ton/ha) as compared to furrow irrigation system, which recorded the lowest values of growth parameters and yield (12 ton/ha). On the other hand the aforementioned parameters were increased with increasing in the amount of water, for these the highest values were recorded with 100% ETc and the lowest values with 50% ETc. The conclusion of this study is that drip irrigation system is convenient for tomato production under semi-arid condition.

Keywords: Tomato; Irrigation systems; Watering, Evapotranspiration

1. Introduction

The limited fresh water is a severe problem throughout the world and especially in arid and semi - arid regions, which is considered the major constraint to crop production, (Kamal, 2009 and Panigrahi et al. 2012). Therefore, optimal and efficient use of available water will alleviate the effect of this problem, on short and long term. Efficient and optimal use of irrigation water require accurate determination of crop water requirements, in order to assist the farmers in deciding when and how much to irrigate their crops. Hence, estimation of evapotranspiration is important for irrigation systems design and water resources management, (Heydari et al. 2015). The efficient use of water on field level, will lead to save water and improve quantity and quality of crops production, (Panigrahi et al. 2012). Drip irrigation is one of the most efficient irrigation systems, that can play a significant role in solving the water scarcity problem, due to uniformly distribute water and it has advantages over conventional surface irrigation as an efficient means of applying water, (Camp 1998), reduces evapotranspiration and decreases the use of water and fertilizer, saves about 70% to 80 % water and increases plants yield (Yildirim and Korukcu, 2000 and Ozbahce and Tari 2010).

Tomato (Lycopersicon esculentum) is one of the most important crops in the world. Jensen et al. (2010) stated that tomato crop sensitives to water stress, therefore, to improve its productivity water supply need to be available throughout the season. In Sudan tomato crop irrigates with the conventional furrow irrigation system and the quantity of irrigation water applied depends on the farmer’s behaviors. Therefore, tomato either receives irrigation water in excess or less than required. In South Darfur State, drip irrigation system is used amongst the other irrigation systems. But the management of this system is not scientifically-based, just on the experience and judgment of the farmer. Nevertheless, Among the different irrigation systems used to irrigate tomato, drip irrigation was found a viable option for its many advantages, such as the possibility to be used with low water availability, high efficiency, lowest incidence of diseases and leading to high yield and fruit quality (Meric et al. 2011 and Panigrahi et al. 2012). Semiz; and

Yurtseven (2011), stated that the yield of tomato tend to increase with proper watering. Also they reported that drip irrigation system has a highest performance based on tomato yield in compared with furrow irrigation system. While Hanson, and May (2003), stated the same result for drip irrigation in comparison with sprinkler irrigation system. Therefore the aim of this study was to quantify the response of tomato (Lycopersicon esculentum Mill) to different irrigation watering amounts (100%, 75% and 50% of ETc) under drip and furrow irrigation systems.

2. MATERIALS AND METHODS

2.1 Materials

The study was conducted at the Farm of Agricultural Renaissance located at Nyala, South Darfur State at 24^o 53′ E, 12^o 3′ N and 674m above m.s.l., during the season 2013/2014 in an area of 0.42 ha. The region is classified as semi-arid with great variation in temperature and rainfall. The weather is very hot in summer with average maximum temperature of 38^oC, and cold in winter with average minimum temperature of 22^oC.

Two irrigation systems (drip and furrow) with three irrigation watering amount: (100%, 75% and 50% ETc of tomato crop), were used. The experiment was arranged in a split plot design with three replicates. The irrigation systems were allocated to the main plots and the amounts of irrigation water were assigned to the subplots.

The crop water requirement was estimated by CROPWAT computer model version 2003.

Drip irrigation consisted of a head control unit, filter, pressure gauges, fertilizer injector, pressure regulators and polyvinyl chloride (PVC) distribution network. The distribution network consisted of a main line (16 cm diameter), sub main (6 cm diameter) and 12 laterals per sub main (2.5 cm diameter).

2.2 Methods

Water measurement

The amounts of irrigation water were measured by flow meters, which were fixed in the sub main lines to read the cumulative amount of water before and after each irrigation event. The drip distributers were adjusted before irrigation. The furrow irrigation water was measured volumetrically (Michael 2009). To calibrate flow meters, stop watch was used for recording the time required to fill a reservoir of a known volume (Michael 2009).

Determination of tomato water requirement

Estimation of water requirement (ETc) is the product of the reference evapotranspiration (ETo) and the crop coefficient (Kc). The reference evapotranspiration was estimated based on the FAO Penman-Monteith equation, using climatic data (Hanson, and May 2004).

Discharge measurement

Measuring cylinder of 25 (ml) volume and containers were used to measure the accumulated discharge for the selected drip distributers. A digital watch was used to record the time. The discharge was measured at different positions of the lateral.

$$ETc = ETo*Kc*Ks*Kr \quad [1]$$

Where:

ETc = Crop evapotranspiration (mm/day).
ETo = Reference evapotranspiration (mm/day).
Kc = Crop Coefficient (dimensionless).
Ks = Soil water availability factor.
Kr = A reduction factor.

A reduction factor (Kr) was calculated from the ground cover value (GC). It is defined as the fraction of the total surface area actually covered by the foliage of the trees when viewed directly from above. In order to calculate GC, the diameter of shaded area (cm) was taken after mid-day. The ground cover, as percentage was calculated by the procedure described by (Hellman, 2004) as follows:

Area per tree = Row width ×Tree spacing within row [2}
Shaded area per tree = Tree spacing within row × D [3]
GC%=(shaded area per tree)/(area per tree) [4]

Where:

D = Average width of measured shaded area between two trees.
GC = Ground cover (%).

The reduction factor (Kr) was estimated using equation (3) as suggested by (Keller and Bliesner 1990) and (Esmail, 2002):

$$Kr=0.1GC^{0.5} \quad [5]$$

Where:

Kr = The reduction factor.
GC = Ground cover (%).

Plant height, stem size and yield ton/ha

The aforementioned parameters were measured randomly from ten plants for each plot. The plant height (cm) was determined from the ground surface to the tip of the main shoot. Stem size (cm) was measured using vernia scale. The yield of each plot was harvested and weighed using balance and then divided by the area of plot to give the yield in (ton/ha).

3. RESULTS AND DISCUSSIONS

As shown in Table 1. The comparison was made between irrigation systems at P≤ 0.05 level of significant. it is recognized that plant height, stem size and yield of tomatoes, irrigated by drip system have superiority over that irrigated by furrow system. The superiority of drip irrigation may be attributed to the fact that drip system distributes water evenly among plants and provides the crop with adequate water requirement as compared to furrow irrigation system. The result in agreement with that of Meric et al.(2011).

On the other hand the deficit irrigation treatment was assessed under both irrigation system (table 2). The maximum values of aforementioned parameters were obtained with 100% ETc, followed by 75% ETc and 50% ETc. This may be due to fact that water applied at 100% Etc adequately meets the crop water requirement. This result is in agreement with the findings of Yildirim and Korukcu (2000), Ozbahce and Tari (2010), who reported that plant growth parameters and yield decreased with increasing in water deficit.

As presented in Fig. 1, 2 and 3, the interaction between irrigation systems and amounts of irrigation water significantly (P ≤ 0.05), effected the investigated parameters. Drip irrigation system at 100%, 75% and 50% of ETc gave the highest values of plant height, stem diameter and yield as compared with that of the furrow irrigation system, respectively. These results are in conformity with those obtained by Semiz and Yurtseven (2011). Who stated that the yield of tomato tend to increase with proper watering, and they reported that drip irrigation system has highest performance based on tomato yield in compared to furrow irrigation system.

Table 1. Effect of irrigation systems on the growth parameters of tomato

irrigation system	Growth parameters		
	Plant height (cm)	Stem size (cm)	Productivity (ton/ha)
Drip	70[a]	1[a]	23[a]
Furrow	58[b]	0.8[a]	12[b]
LSD	9.6	0.5	7.7

Means with the same letter (s) in the same column are not significantly difference at P ≤ 0.05

Table 2 Effect of watering amount on the growth parameters of tomato

Watering amount	Growth parameter		
	Plant height (cm)	Stem size (cm)	Productivity (ton/ha)
100% ETc*	72a	1.2a	24a
75% ETc	69b	1a	22b
50% ETc	50c	0.8a	12c
LSD	2.5	0.7	1.5

Means with the same letter (s) in the same column are not significantly difference at P ≤ 0.05.
*ETc = crop water requirement

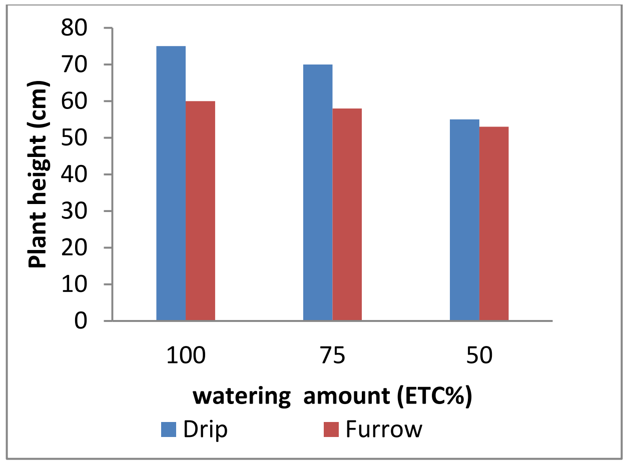

Fig. 1 Effect of irrigation systems and watering amount on the plant height (cm) of tomato

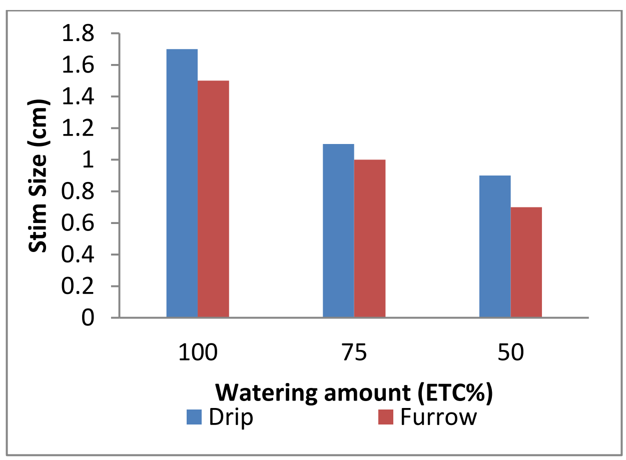

Fig. 2 Effect of irrigation systems and watering amount on the stem diameter (cm) of tomato

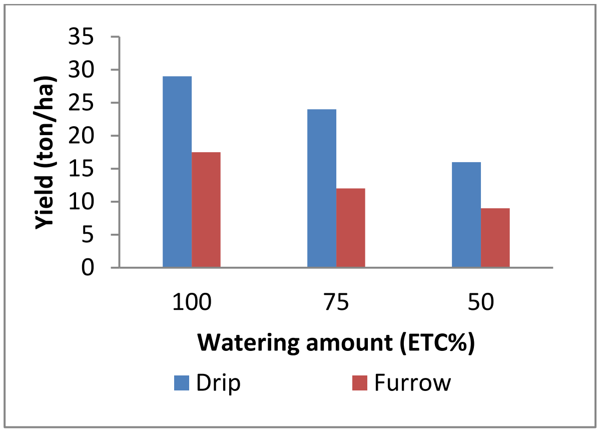

Fig. 3 Effect of irrigation systems and watering amount on the yield (ton/ha) of tomato

4. CONCLUSIONS

For maximum production in dryland, tomato should be irrigated using drip irrigation system with 100% ETc watering amount.

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