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Original Research Article

Effect of automated drip irrigation system on yield and water use efficiency of tomato (*Solanum lycopersicum* L.)

ABSTRACT: Field experiment was conducted to evaluate the performance of different automated drip irrigation on tomato crop under sandy clay loam soil in TNAU during *kharif* 2019 and 2020. Five treatments comprising of 4 different automated drip irrigation system are time based drip irrigation, volume based drip irrigation, soil moisture sensor based irrigation, switching tensiometer based irrigation and one is surface method of irrigation were tested. The results revealed that tensiometer based drip irrigation recorded higher fruit yield (95.11 and 96.21 t ha^{-1}) and WUE (21.10 and 25.42 t $ha\text{-}mm^{-1}$) resulting in increment over conventional method of irrigation. However, the above treatment was followed by soil moisture sensor based drip irrigation in tomato. Tensiometer based drip irrigation helps to save the water up to 54.91 and 60.55 % compared to conventional method of irrigation.

Keywords: Tomato, automated drip irrigation, fruit yield, WUE

Introduction

Water is becoming gradually scarce worldwide as a result of a combination of population expansion, socioeconomic development, shifting consumption patterns and climate change which has resulted in water shortages and poor quality of water. Present day, agriculture is India's largest consumer of water, it is now necessary to reduce consumption, enhance water resource management and productivity of food crops need to be increased by 60-70 % during mid-century to keep the country self-sufficient[16]. Several modern techniques for irrigating the crops will increase the water use efficiency. Drip irrigation is most effective technique which supplies water near the root zone leads to save more water. Recent days, farmers in India practiced irrigation technique through manual control. This process

Comment [A1]: Who said this issue? (please noted if from literature reference) sometimes consumes more water and deliver late to the root zone leads to crop get dried. To overcome this problem can adopt automatic drip irrigation system along with sensors which are installed in the root zone and connected to an irrigation controller. Sensors measures the moisture content and send values to valve of the system to turn ON and OFF automatically for various intervals of time. Please add the beneficial effect of drip irrigation for crop irrigation compared other system.

Tomato is one of the most preferred vegetables all over the world. Tomato ranks second followed by potato in terms of area cultivated, but first as a processing crop[7]. In India about 83 % of the fresh water resources are utilized for agriculture purposes. Tomatoes cover 5,023,810 hectares of land around the world[5]. However, Tomato crop requires 400 - 800 mm of water for total cropping period. Although, tomato is sensitive to water stress and it has a high correlation between evapotranspiration (ET) and crop yield[12]. In the successful cultivation of Tomato, Plant development and yield are heavily influenced by water[2]. They are very sensitive to water deficits during transplanting, at flowering and also during fruit development. Water stress will inhibit the growth higher at initial stage (20th day) compared to the later stage (30th day) of the crop[11]. In general, tomato crop irrigates through surface method of irrigation (furrow/check basin) wherein losses over conveyance, application, evaporation and percolation are common besides having adverse effects of cyclic over irrigation or water stress. Drip irrigation is good adoption for achieving better productivity and quality in different crops. Micro irrigation is an efficient method which can save water and fertilizers, resulting in higher yield, quality and reduce the labour interventions in farm operations[17]. In the present decade, there has been a serious anxiety in global lack of water. It is assessed that in India by 2025, 33% of India's population will live under severe scarcity conditions[4]. Drip irrigation is the most effective way to supply water to the tomato, which not only saves water but also increases yield due to nonstop maintenance of moisture content near field capacity[14]. Because there is a scarcity of labour to carry out agricultural tasks today, agricultural processes must be automated. Farmers in India have been adopting irrigation techniques through manual control in which they irrigate the field at regular intervals in the modern period. This procedure can use a lot of water, or it can take a long time for the water to reach the crops, causing them to dry out. This problem can be completely solved by using automatic drip irrigation system, in which irrigation occurs only when there is a high demand for water. The objective of this work was to evaluate a different method of automatic irrigation system compare with common grower practice in the area and scheduling methods of irrigation which may help the farmers to enhance the productivity of tomato. What is the water needed by tomato per day. Thus, you propose the drip irrigation system for tomato crop?. What is the reason you propose the drip irrigation system

Materials and methods

The experiment was carried during *kharif* 2019 and *kharif* 2020 at Tamil Nadu Agricultural University, Coimbatore situated at 11° North latitude and 77° East longitude at an altitude of 426.7 m above mean sea level. Weather parameters were obtained from the Agro Climate Research Centre, TNAU. The soil type of the experimental filed was sandy clay loam. Tomato (*Solanum lycopersicum* L.) crop, variety shivam hybrid with 135 days of duration was transplanted at 60 × 60 cm spacing in all plots grown under irrigated conditions. The experiment was laid out in randomized block design with four replication and five treatments. The treatments consist of 4 different automated drip irrigation systems, viz., T_1-time based drip irrigation (Irrigation at fixed interval per stage and refill soil to field capacity), T_2-volume based drip irrigation (critical depletion along with refill soil to field capacity), T_3-soil moisture sensor based irrigation (EC H_2O- Capacitance sensor), T_4-switching tensiometer based irrigation (Irrometer) and T_5-conventional method of irrigation (furrow irrigation). To evaluate the different methods of automated drip irrigation system over surface irrigation, all agronomic practices such as weeding, disease and pest control were carried out according to the conditions. Data on yield components of tomato crop were observed and analysed from the treatment plots. These data were also necessary for calculating total water use, water saving percent and water use efficiency. Please add the soil propertis was used in this experiment!

Comment [A2]: What is type of soil. Sandy soil or clay soil. I think if you propose drip irrigation because sandy soil is porous. Give the name of soil classification

Estimation of crop water requirement

The test crop was tomato (*Solanum lycopersicum* L.) The crop cycle length was 135 days with development stages of initiation, vegetative, reproductive and maturity stages, respectively. The actual crop evapotranspiration was (ETa) calculated by multiplying the reference evapotranspiration (ETo) with crop coefficient (Kc) for different growth stages of the crop. The major input data has been used in CROPWAT model was climatic data, crop data and soil data. Climatic data of previous year (2016-2018) were collected from ACRC, TNAU (Figure 1). The results derived from the CROPWAT model are used for experimental trial on scheduling automated drip irrigation for time based and volume based irrigation. Soil moisture sensor (EC- H_2O) based irrigation depends on resistivity principle, transmits the real data of soil moisture content to microcontroller and irrigation event take place automatically as per availability of moisture content with respect to predefine value stored in data base of controller for irrigation scheduling. Switching tensiometer irrigation depends on soil moisture tension above 0.45 bars. To evaluate conventional method of irrigation, the climatic data of 2019 and 2020 were collected from ACRC and used to calculate irrigation water requirement as per the IW/CPE ratio of 0.8 for tomato.

Estimation of water use studies:

Total water use (mm)

It is the sum of irrigation water applied during cropping period and effective rainfall.

$$\text{Total water use (mm)} = Totalirrigation\ water + Effective\ rainfall$$

Field water use efficiency (t ha-mm^{-1})

Field water use efficiency (WUE) is the yield that can be produced from a given quantity of water with effective rainfall utilized by the crop (total water use).

$$\text{WUE} = \frac{\text{yield}}{\text{Total water use}} \times 100$$

Percent of water saving over control

Water saving % calculated by subtracting the total water utilized in treatments with total water consumed for conventional method of irrigation and then divided by total water consumed for conventional method of irrigation. From the derived values were multiplied by 100 to get percent of water saved over control treatment.

Statistical analysis: Data collected from the field experiment were statistically analysed using "Analysis of variance test" at 5 % critical difference over each other[9].

Results and Discussion

Fruit yield (t ha^{-1})

The maximum fruit yield of tomato was recorded with sufficient water to the crop (Table 1). During *kharif* 2019, tensiometer based drip irrigation gave significantly higher yield (95.11 t ha^{-1}) over surface irrigation (62.13 t ha^{-1}). During *kharif* 2020, the highest fruit yield (96.21 t ha^{-1}) was recorded under tensiometer based drip irrigation over surface irrigation (62.69 t ha^{-1}). The yield of 33 per cent were recorded with tensiometer based drip irrigation method over conventional method of irrigation during *kharif* 2019 and *kharif* 2020.The higher yield under tensiometer based drip irrigation might be due to application of required amount of water to the crop at required time. Similar results conveyed that utilizing switching tensiometers in Florida lowered irrigation requirements of tomatoes by 40–50% without dropping fruit yield[18]. Fruit yield of tomato was higher up to 7% with drip irrigation over furrow method of irrigation[15].

Water use studies

The total water utilized is given in Table 1, including effective rainfall for tomato crop. It can be seen that the total water used for tomato crop was higher for conventional method of irrigation which was irrigated during transplanting at 5 cm depth. Subsequently irrigation was given in accordance with the IW/CPE ratio of 0.8. Quantity of water applied was 583 and 750 mm during *kharif* 2019 and *kharif* 2020, respectively. An effective rainfall of 416 and 209 mm was received during the cropping period in *kharif* 2019 and 2020, respectively. The quantity of water used about 999 and 959 mm during *kharif* 2019 and 2020 for surface irrigated crops followed by time based drip irrigation (624 and 568 mm), volume based drip irrigation (470 and 418 mm), soil moisture sensor based drip irrigation (462 and 406mm) and tensiometer based drip irrigation (451 and 378 mm) treatment during both the years. The highest water use efficiency of 21.10 and 25.42 t ha-mm^{-1}was obtained for tensiometer based drip irrigation treatment which was followed by soil moisture sensor based drip irrigation treatment (20.29 and0.23.31 t ha-mm^{-1}). The lowest water use efficiency (6.22 and 6.53 t ha-mm^{-1}) was noticed with control treatment during *kharif* 2019 and *kharif* 2020 (Figure 2). Tensiometer based drip irrigation recorded a water saving percent of 54.91 and 60.55 percent over conventional irrigation during *kharif* 2019 and *kharif* 2020 (Table 1). The reason behind increased in WUE and less quantity of water utilized for all drip irrigation method was due to considerable saving of irrigation water, greater increase in crop yield. Similar results revealed the comparative performance of drip and surface methods of irrigation in tomato and stated that there is a water savings of 20-52 % over surface method of irrigation[13].Furthermore, low irrigation regime condensed deep percolation and enlarged water use by plants from the root zone soil[3]. Decrease in irrigation water requirements in Florida region which displays that using tensiometer, the irrigation requirement of tomato crop was condensed by 40 to 50% but they need regular maintenance and blockage owing to algae growth[6]. The WUE was lower and total water use was greater in surface irrigation than other irrigation method. It might be due to higher consumption of water resulting in lower yield than other treatments.

Conclusion

An automated irrigation system providing water on-demand was designed using time based, volume based, sensor based, tensiometer based drip irrigation proves to be a real time feedback control system which efficiently monitors and controls all drip irrigation system activities. The findings will be utilised to modernise farm operations on a wider scale as well as save manpower, water and ultimately money by increasing productivity. The present study indicated that tensiometer based drip irrigation resulted in significantly highest yield (95.11 and 96.21 t ha^{-1}) and water use efficiency (21.10 and 25.42 t $ha\text{-}mm^{-1}$) than the conventional method of irrigation in tomato during *kharif* 2019 and *kharif* 2020.

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Table 1: Effect of automated drip irrigation on yield (t ha^{-1}) and Total water use (mm) of tomato

Treatment	Yield (t ha^{-1})		*Total water use (mm)		*Water saving (%)	
	***kharif* 2019**	***kharif* 2020**	***kharif* 2019**	***kharif* 2020**	***Kharif* 2019**	***Kharif* 2020**
T1- Time based drip irrigation	88.22	89.90	624	568	37.61	40.79
T2- Volume based drip irrigation	91.53	92.26	470	418	53.02	56.48
T3- Soil moisture sensor based drip irrigation	93.79	94.78	462	406	53.76	57.64
T4- Tensiometer	95.11	96.21	451	378	54.91	60.55

based drip irrigation						
T5- Conventional method of irrigation	71.55	72.38	999	959	-	-
Sed	0.50	0.39	-	-		
CD (P=0.05)	1.09	0.86	-	-		

* Data not statistically analysed

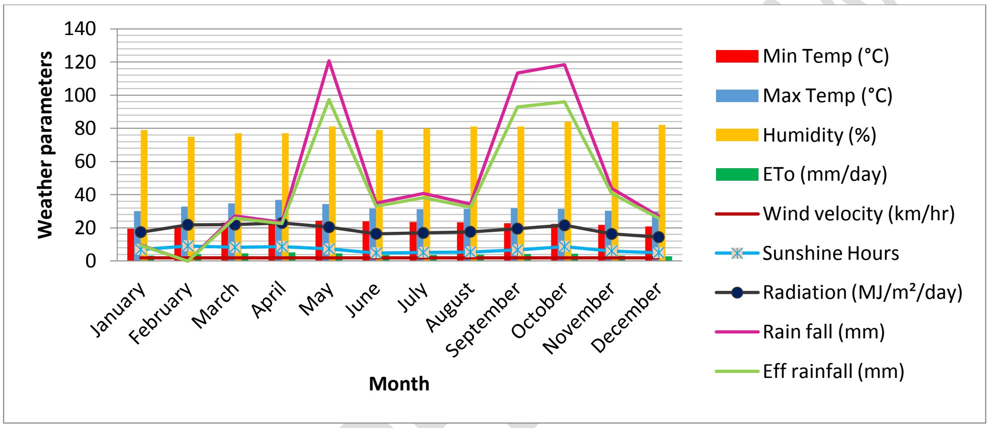

Figure 1: Weather parameters prevailed during 2016-2018

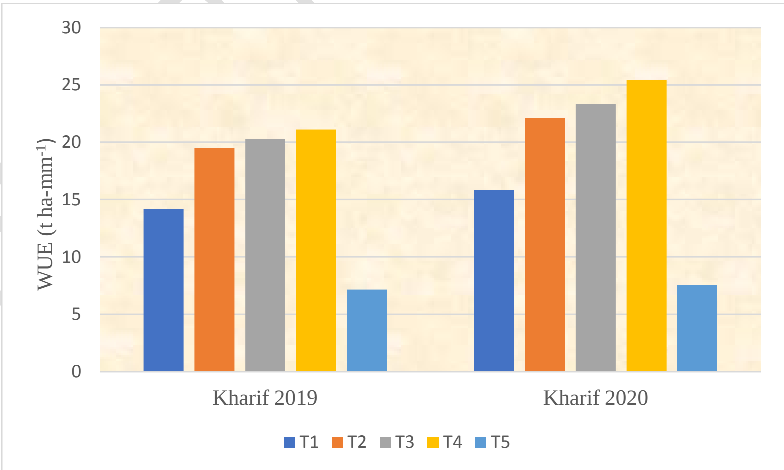

Figure 2. Effect of different automated drip irrigation on water use efficiency (t ha-mm^{-1}) of tomato during *kharif* 2019 and *kharif* 2020