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Response Of Tomato Crop To Different Irrigation Levels And Dripper Discharge Rates

G. PRASANNA[1], G. MANOJ KUMAR[1], M. SRINIVASULU[1] AND S.D. HUSSIAN[2]
[1] Department of Agricultural Engineering, CAE, Kandi, PJTSAU
[2] Department of Agronomy, College of Agriculture, Rajendranagar, PJTSAU
*Corresponding author E-mail: prasannaguda11@gmail.com

ABSTRACT
The aim of this study was to determine the performance of growth parameters and yield of tomato crop with two irrigation levels (0.8 ETc and 1.0 ETc) and four dripper discharge rates (1.6 lph, 2.2 lph, 3.0 lph and 4.0 lph). The experiment was conducted in a sandy clay loam soil under semi- arid climate conditions of Hyderabad in rabi 2016-2017. Irrigation water was applied using pan evaporation method with two days irrigation intervals. During the experiment five samples were collected from each treatment to determine growth parameters for each treatment. Results showed the growth parameters and yield were highest in 0.8 ETc than 1.0 ETc. Significantly among dripper discharge rates highest yield was obtained from 1.6 lph followed by 2.2, 3.0 and 4.0 lph. Among the irrigation levels the yield and water use efficiency was higher for crop irrigated at 0.8 ETc then 1.0 ETc. Hence irrigation water could be saved by irrigating at 0.8 ETc with 1.6 lph dripper discharge rate.
Keywords: *Dripper discharge rate, Irrigation levels, tomato, water use efficiency*

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INTRODUCTION

Water is the primary source of life for mankind and one of the most basic necessities for crop production. For sustainable production from agricultural farms, irrigating the crops at right stages is highly important. Even in rainfed situation, life saving irrigation during long dry spell has also been found beneficial for crop survival and to obtain the targeted yield. Water availability is an important constraint for plant productivity, mostly affecting the growth of leaves and roots, stomatal conductance, photosynthesis, and dry matter accumulation. To meet the need of gradually growing demand of crop production modernizing the irrigation services through existing resources is a challenge to researchers. One solution to this problem is the use of drip irrigation system which improves profitability by increasing crop yield and quality while at the same time reducing the cost on water, energy, labour and chemical inputs.

Tomato *(Solanum Lycopersicum)*, native of Peru-Ecuador-Bolivian area of South-America. It is most widely grown vegetable crop in the world as well as in India. It is one of the most popular and widely grown vegetable in the world ranking second in importance. In India, tomato crop occupies an area of 0.76 million hectare with an estimated production of 18.39 M tonnes (National Board of Horticulture, 2015-2016). It is an important source of vitamins and an important cash crop for small holders and medium-scale commercial farmers. Tomato belongs to the genus Solanum under Solanaceae family.

The water distribution and its movement in the drip irrigation depends upon many parameters like soil type, crop cultivars, crop planting pattern, discharge rate of drippers, amount of water applied, climatic factors ETc. The present study was undertaken to "Evaluate response of tomato crop to different irrigation levels and dripper discharge rates

MATERIAL AND METHODS

A field experiment was conducted during *rabi* (Oct-Feb) season of 2016-17at college farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rajendranagar, Hyderabad, to evaluate the effect of irrigation levels and dripper discharge rates on yield of tomato crop.

The experimental farm is geographically situated in the southern part of Telangana at 17° 50' N latitude and 80° 00' E longitude with an altitude of 542.6 m above mean sea level. The geographical area of Hyderabad comes under tropical and semi-arid region. The experimental soil was sandy clay loam in texture, moderately alkaline in reaction. The treatments were laid out in split plot design with two irrigation levels (0.8 ETc (I_1) and 1.0 ETc (I_2)) as main plot treatments and four discharge rates (1.6 lph (D_1), 2.2 lph (D_2), 3.0 lph (D_3) and 4.0 lph (D_4)) as sub-plot treatments with three replications. Mean weekly maximum temperatures ranged from 27.9 ^{0}C to 31.90 ^{0}C, while mean weekly minimum temperatures varied from 8.9 ^{0}C to 21.90 ^{0}C during crop growth period. With respect to pan evaporation, mean pan evaporation ranged 3.1 to 5.3 mm/day.

Each plot was 3.6 m wide and 10 m long and twenty eight days well grown tomato seedlings were transplanted with lateral spacing of 1.2 m apart by maintaining crop geometry of 40 x 40 cm with paired row planting. Water requirement of tomato was estimated on the basis of reference crop evapotranspiration (ETo) on the daily basis by using Pan evaporation method. The crop evapotranspiration (ETc) was estimated by multiplying reference evapotranspiration (ETo) with crop coefficient (Kc), i.e. ETc = ETo × Kc. The application rate and irrigation time were calculated by using following formulae.

$$\text{Application rate (mm/h)} = \frac{Q}{Sl \; X \; Se}$$

$$\text{Irrigation time (minutes)} = \frac{ET_c \; X \; WP \; X \; 60}{Application \; rate}$$

Tomatoes were harvested at different dates after attaining maturity. The crop was harvested from 20th January to 13th February 2016. The statistical analysis was done to obtain the effect of different irrigation levels and dripper discharge rates on plant growth parameters like plant height (cm), root length (cm), dry matter production (g plant^{-1}), yield (t ha^{-1}).

RESULTS AND DISCUSSION

Plant height (cm)

The data on plant height (cm) during 30, 60, 90 Days After Transplanting (DAT) and at harvest was presented in Table 1 and depicted in the Figure 1.The results indicated that plant height was maximum when crop was irrigated with 0.8 ETc than 1.0 ETc.

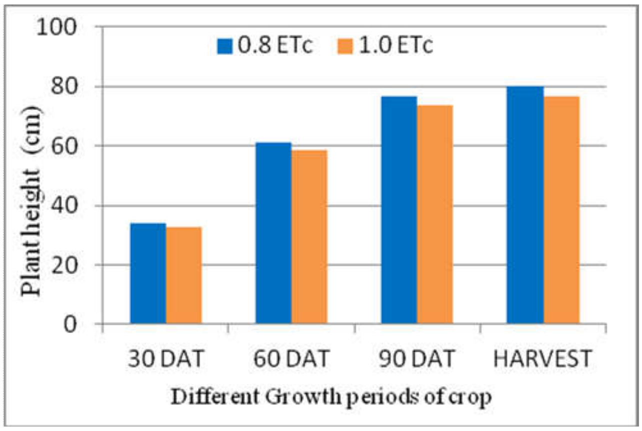
Significantly maximum plant height (36.53, 62.47, 79.88 and 81.99 cm) was recorded with dripper discharge rate of 1.6 lph during 30, 60, 90 DAT and at harvest respectively followed by 2.2, 3.0 and lowest was recorded with 4.0 lph drippers. The results showed that with decrease in discharge rates there is increase in plant height that might be due to uniform availability of soil moisture in the root zone without any stress which facilitate to production of better root biomass resulting better nutrient uptake from the soil. Similar trend was also reported by Yohannes and Tadesse (1998).

The interaction of irrigation levels and discharge rates were non-significant in recording the plant height at all stages of plant growth including harvest. An overview of the comparison of different dripper discharge rates on plant height indicated that with decrease in discharge rate there is increase in plant height. The results obtained are in line with Rajurkar *et al.* (2015).

Table 1. Plant height (cm) at different growth periods influenced by different irrigation levels and dripper discharge rates during *rabi* 2016-17

Treatment		Plant height (cm)			
Main Factor		30 DAT	60 DAT	90 DAT	HARVEST
0.8 ETc		34.13	61.02	76.71	80.20
1.0 ETc		32.72	58.39	73.51	76.84
SEm ±		0.167	0.393	0.503	0.389
CD(0.05)		1.097	2.573	3.292	2.537
Sub Factor					
1.6 lph		36.53	62.47	79.88	81.99
2.2 lph		35.25	60.76	76.52	79.55
3.0 lph		31.65	58.26	74.10	77.91
4.0 lph		30.28	57.33	69.93	74.61
SEm ±		0.499	0.570	0.796	0.407
CD(0.05)		1.553	1.776	2.481	1.268
0.8 ETc	1.6 lph	37.07	64.06	81.10	83.85
	2.2 lph	35.93	62.53	78.67	81.41
	3.0 lph	32.53	59.27	76.17	79.40

	4.0 lph	31.00	58.28	70.88	76.13
1.0 ETc	1.6 lph	36.00	60.87	78.65	80.15
	2.2 lph	34.57	58.99	74.34	77.69
	3.0 lph	30.77	57.31	72.03	76.42
	4.0 lph	29.57	56.38	68.98	73.09
Interaction					
SEm ±		0.6327	0.80	1.005	0.631
CD(0.05)		NS	NS	NS	NS



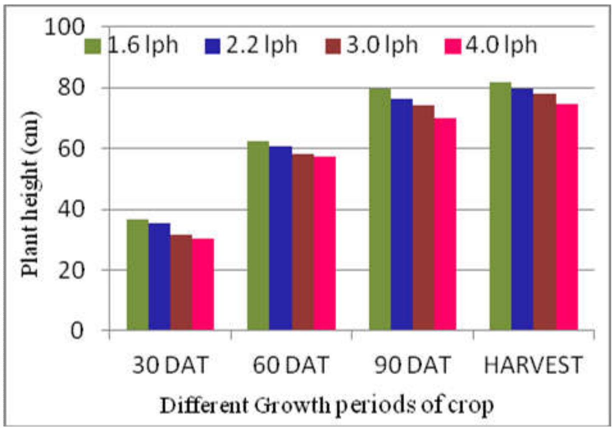


Figure 1. Plant height (cm) at different growth period influenced by different irrigation levels and dripper discharge rates during *rabi* 2016-17

Dry matter production (g plant^{-1})

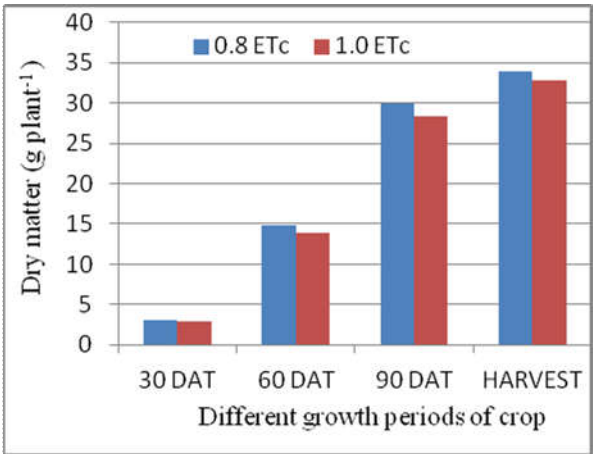
The data obtained on dry matter production of tomato at 30, 60, 90 DAT and at harvest are presented in Table 2 and depicted in Figure 2. Drip irrigation scheduled at 0.8 ETc showed significantly highest dry matter production at 1.0 ETc at all the stages of crop growth period. Dry matter production among the discharge rates showed increase with decrease in discharge rates throughout crop growth period.

The interaction effect of irrigation levels and discharge rates were non-significant in recording the dry matter production at all stages. Due to the optimum distribution of moisture in discharge rate of 1.6 lph it has recorded highest dry matter production and the dry matter production decreased significantly with increase in discharge rate for all the growth stages of plant. The discharge rate of 1.6 lph i.e slow and continuous availability of irrigation water must have lead to better nutrient uptake and growth of the plant which resulted in better dry matter production at lower discharge rates. The present results obtained are in line with the findings of Ragheb *et al*. (2011).

Table 2. Dry Matter production (g plant^{-1}) at different days influenced by different irrigation levels and dripper discharge rates during *rabi* 2016-17

Treatment		Dry matter production (g plant^{-1}) *rabi*, 2016			
Main Factor		30 DAT	60 DAT	90 DAT	HARVEST
0.8 ETc		3.02	14.79	29.87	33.99
1.0 ETc		2.95	13.90	28.28	32.79
SEm ±		0.027	0.119	0.212	0.081
CD(0.05)		NS	0.781	1.390	0.527
Sub Factor					
1.6 lph		3.24	16.82	32.55	36.48
2.2 lph		3.03	14.87	29.73	35.42
3.0 lph		2.90	13.32	27.63	31.83
4.0 lph		2.78	12.38	26.38	29.83
SEm ±		0.023	0.191	0.393	0.322
CD(0.05)		0.071	0.596	1.225	1.005
0.8 ETc	1.6 lph	3.33	17.33	33.30	37.07
	2.2 lph	3.03	15.23	30.70	36.03
	3.0 lph	2.93	13.97	28.37	32.53

	4.0 lph	2.80	12.63	27.10	30.33
1.0 ETc	1.6 lph	3.14	16.30	31.80	35.90
	2.2 lph	3.02	14.50	28.77	34.80
	3.0 lph	2.87	12.67	26.90	31.13
	4.0 lph	2.77	12.13	25.67	29.83
Interaction					
SEm ±		0.039	0.263	0.526	0.403
CD(0.05)		NS	NS	NS	NS



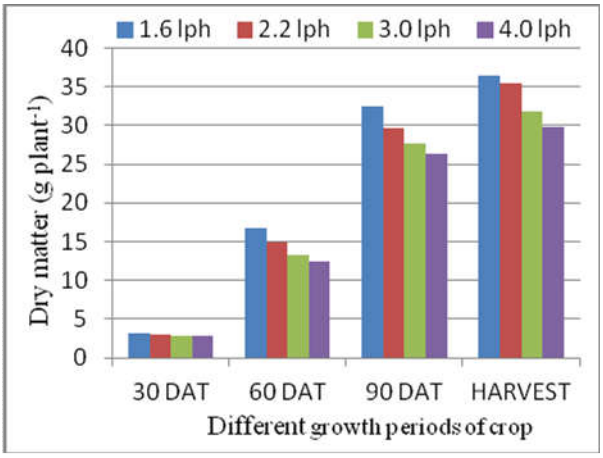


Figure 2. Dry matter production (g plant^{-1}) at different growth periods influenced by different irrigation levels and dripper discharge rates during *rabi* 2016-17

Root length (cm)

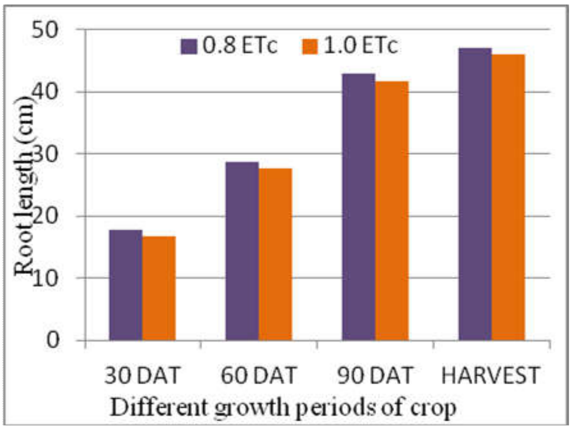
The data on the root length affected by irrigation schedules of 0.8 ETc and 1.0 ETc at all growth stages of the crop and dripper discharge rate result presented in Table 3 and depicted in Figure 3. Root length is significantly affected by irrigation schedules of 0.8 ETc and 1.0 ETc at all growth stages of the crop except at 30 DAT. The difference in root length under irrigation schedules was not significant at 30 DAT due to uniform application of irrigation treatments to all the treatment plots in the initial stages to ensure optimum plant population.

Among the discharge rates significantly higher root length (18.78, 31.14, 45.55 and 50.12 cm) at 30, 60, 90 DAT and harvest was noticed with dripper discharge rate of 1.6 lph than all other discharge rates followed by 2.2, 3.0 and 4.0 lph. On the other hand root length observed with discharge rate of 3.0 lph was on par with 4.0 lph discharge rate at 30 and 60 DAT. Lower root length (15.99, 25.97, 39.41 and 43.29 cm) was recorded with 4.0 lph at 30, 60, 90 DAT and harvest respectively than all other discharge levels. The interaction levels of irrigation and discharge rates the root length of tomato was found to be non-significant. However the irrigation with drip at 0.8 ETc at 1.6 lph discharge level has recorded the highest root length (19.72, 32.23, 46.22 and 51.20 cm) followed by the crop irrigated at 1.0 ETc with 1.6 lph discharge rate. Higher discharge rates result in more lateral flow of water than vertical flow and lesser discharge rate results in more vertical flow than lateral flow (Shrivastava *et al.*, 2012) which may be the reason for the longest root development in low discharge rate than in higher discharge rates. The results obtained are in line with Vijay Kumar *et al.* (2012).

Table 3. Root length (cm) at different days influenced by different irrigation levels and discharge rates during *rabi* 2016-17

Treatment	Root length (cm)				
Main Factor		30 DAT	60 DAT	90 DAT	HARVEST
0.8 ETc		17.84	28.66	43.01	47.08
1.0 ETc		16.79	27.62	41.62	46.08
SEm ±		0.273	0.146	0.177	0.035
CD(0.05)		NS	0.928	1.162	0.177
Sub Factor					
1.6 lph		18.78	31.14	45.55	50.12
2.2 lph		17.86	28.64	43.02	47.85
3.0 lph		16.65	26.82	41.29	45.07

4.0 lph		15.99	25.97	39.41	43.29
SEm ±		0.285	0.299	0.459	0.416
CD(0.05)		0.877	0.931	1.414	1.298
0.8 ETc	1.6 lph	19.72	32.23	46.22	51.20
	2.2 lph	18.5	29.10	43.81	48.68
	3.0 lph	16.91	27.16	41.97	45.06
	4.0 lph	16.24	26.16	40.05	43.38
1.0 ETc	1.6 lph	17.83	30.04	44.87	49.04
	2.2 lph	17.22	28.17	42.23	47.01
	3.0 lph	16.39	26.47	40.61	45.07
	4.0 lph	15.74	25.79	38.77	43.20
Interaction					
SEm ±		0.442	0.392	0.589	0.512
CD(0.05)		NS	NS	NS	NS



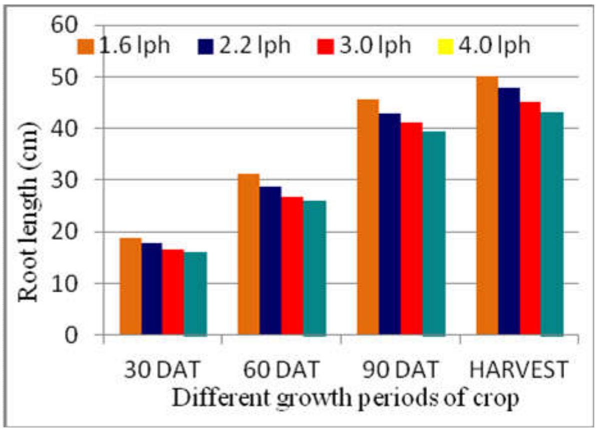


Figure 3. Root length (cm) at different growth period influenced by different irrigation levels and dripper discharge rates during *rabi* 2016-17

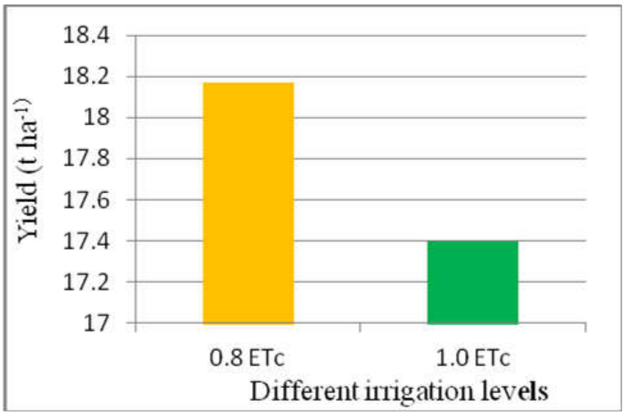
Yield (t ha^{-1})

The effect of irrigation levels and discharge rates on crop yield is presented in Table 4 and depicted in Figure 4.The results showed that significantly highest yield was recorded at 0.8 ETc (18.167 t ha^{-1}) irrigation level and lowest was observed for 1.0 ETc (17.399 t ha^{-1}). Similarly among the four discharge levels i.e. 1.6, 2.2, 3.0, 4.0 lph the crop irrigated with 1.6 lph has recorded significantly highest yield (20.482 t ha^{-1}) followed by 2.2 lph discharge rate and lowest yield was recorded by 4.0 lph (15.287 t ha^{-1}). At interaction levels yield was significant and the irrigation level of 0.8 with 4.0 lph recorded the highest yield of 20.809t ha^{-1} and lowest was recorded with 4.0 lph (14.804 t ha^{-1}) at 1.0 ETc. The yield of tomato crop was recorded superior at 0.8 ETc than at 1.0 ETc probably due to favourable moisture and air balance available at root zone resulted in maintaining the optimum micro climate might enhanced the rate of photosynthesis and absorption of plant nutrients along with irrigation water. Increased irrigation duration with lower discharge rates improve the yield. Similar results were observed by Badr and Talab (2007) in vegetable crop tomato.

Table 4. Effect of different discharge rates and irrigation levels on yield (t ha^{-1}) at harvest during *rabi* 2016-17

Discharge rate (lph)	Yield (t ha^{-1})		
	0.8 ETc	1.0 ETc	Mean
1.6	20.809	20.809	20.482
2.2	18.959	18.959	18.532
3.0	17.129	17.129	16.832
4.0	15.769	15.769	15.287
Mean	18.167	17.399	
Comparison between		SEm ±	CD(0.05)
Irrigation level		0.080	0.012
Discharge rates		0.023	0.071

Irrigation level at same or different discharge rates	0.031	0.112
Discharge rates at same irrigation levels	0.163	0.588



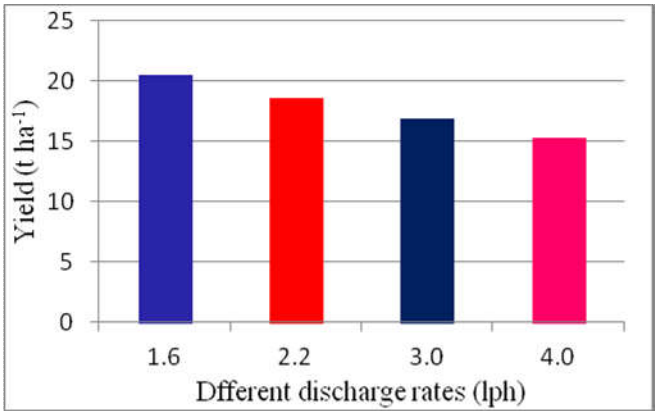


Figure 4. Yield (t ha^{-1}) influenced by different irrigation levels and different discharge rates during *rabi* 2016-17

Water Use Efficiency (kg ha^{-1} mm^{-1})

Water use efficiency indicates yield produced per unit volume of water used. It was computed by taking economic yield of crop and the total water used (including the effective rainfall) into consideration. It can be increased either by increasing the yield or by reducing the quantity of water applied. The results are presented in Table 5 and depicted in Figure 5.

The highest amount of irrigation water applied was 232.33 mm at 1.0 ETc with 4.0 lph dripper discharge and lowest was applied at 0.8 ETc with 1.6 lph discharge rate including effective rainfall of 18.7. The experimental results indicated that the water use efficiency was maximum when the crop was irrigated with the irrigation level at 0.8 ETc which was significantly superior over the crop irrigated with drip at 1.0 ETc

Similarly among all the discharge rates 1.6 lph recorded highest water use efficiency in both the irrigation levels followed by 2.2, 3.0 and 4.0. Due to more yield obtained from less water applied in 1.6 lph the water use efficiency in 0.8 ETc irrigation level shows more water use efficiency than 1.0 ETc. The highest water use efficiency shows a decreasing trend with increase in dripper discharge rate as the yield decreased with increase in discharge rate. The same decreasing trend was obtained from 1.6 lph to 4.0 lph discharge rates in both the irrigation levels due to the decrease in yield obtained due to increase in discharge rate. Similar results were observed by Pragna *et al*. (2016) in vegetable crop cabbage that with increase in dripper discharge rate from 1.6 to 4.0 lph, water use efficiency will be decreased and also reported that increase in soil moisture regime could increase the water productivity up to a certain level, but tends to decline thereafter. The above presented results are in accordance with the findings of Ismail *et al. (*2013).

Table 5. Total amount of water applied during crop growth period *rabi* 2016-2017

Treatments		Yield (t ha^{-1})	Total amount of irrigation water applied (mm)	Water use efficiency (kg ha^{-1} mm^{-1})
0.8 ETc	1.6 lph	20.809	213.08	97.66
	2.2 lph	18.959	214.08	88.56
	3.0 lph	17.129	215.08	79.64
	4.0 lph	15.769	215.08	73.32
1.0 ETc	1.6 lph	20.809	245.03	82.25
	2.2 lph	18.959	247.04	73.28
	3.0 lph	17.129	251.03	65.86
	4.0 lph	15.769	251.03	58.97

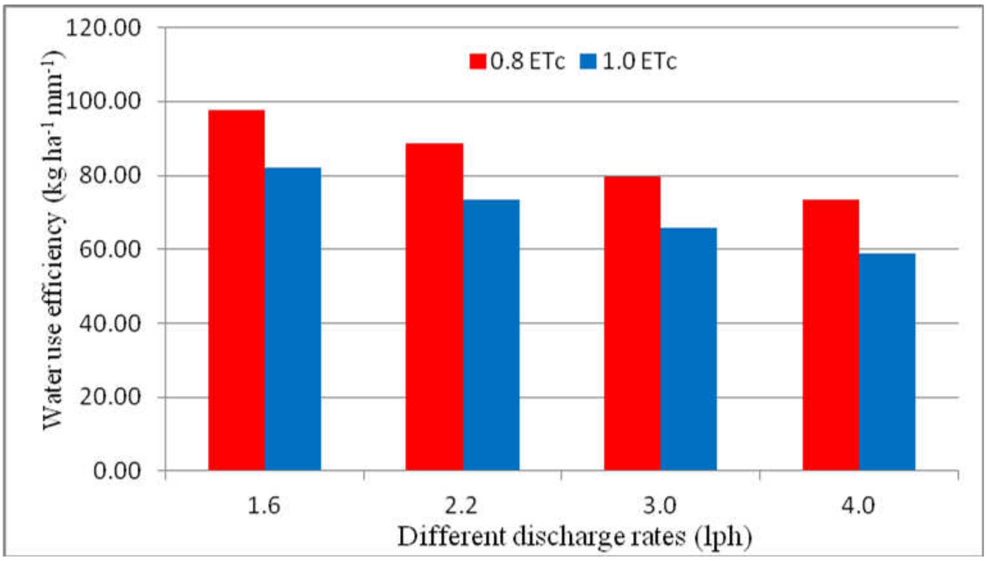


Figure 5. Effect of different discharge rate and irrigation level on water use efficiency (kg /ha-mm)

Among four dripper discharge rates, 1.6 lph significantly gave higher plant height (cm), root length (cm), dry matter production (g plant^{-1}), and yield (t ha^{-1}). Among two irrigation levels (0.8 ETc and 1.0 ETc), crop irrigated at 0.8 ETc gave higher yield and water use efficiency (t/ha-mm). Hence irrigation water could be saved by irrigating the tomato crop at 0.8 ETc. The higher discharge rate due to more water distribution in horizontal direction resulted in less root development and less nutrient uptake which affects the growth of plant. Thus, for irrigation of tomato 0.8 ETc with lower dripper discharge rate would give beneficiary results. The interaction effect of dripper discharge and irrigation levels was non-significant for all parameters.

Conclusions

Among the irrigation levels higher growth parameters, yield and water efficiency was superior for 0.8 ETc than 1.0 ETc. Among four dripper discharge rates growth parameters, yield and water efficiency was highest for lowest discharge rate 1.6 lph. Thus in water scarcity area irrigation water could be saved by irrigating the crop at 0.8 ETc with 1.6 lph dripper discharge rate.

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