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RESEARCH PAPER

Effect of treated and untreated domestic wastewater and fertilizer levels on growth, yield and yield attributes of tomato

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Abstract: A field experiment was carried out to study the effect of treated and untreated domestic wastewater and fertilizer levels on tomato during 2014 and 2015 at the Main Agricultural Research Station, University of agricultural Sciences, Dharwad. The experiment comprised of four irrigation sources (I_1- treated domestic wastewater, I_2- fresh water, I_3- untreated domestic wastewater alternated with fresh water, and I_4- untreated domestic wastewater) and four fertilizer levels (0, 50, 75 and 100 % RDF). The interaction effects of application of untreated domestic wastewater along with 100 per cent RDF resulted in significantly higher plant height (77.93 cm), leaf area (91.57 cm^2), LAI (2.03) and dry matter production (106.03 g plant^{-1}) as compared to other treatment combinations. However, LAI (1.87) and dry matter production (93.04 g plant^{-1}) were found on par with treatment receiving treated domestic wastewater along with 100 per cent RDF(250:250:250 kg N, P_2O_5 and K_2O ha^{-1}). Among irrigation sources significantly higher yield parameters like average fruit weight and fruit diameter were noticed with application of either treated or untreated domestic wastewater as compared to other irrigation sources. Fruit yield differed significantly due to application of different sources of irrigation and fertilizer levels. Among irrigation sources significantly higher fruit yield (58.20 t ha^{-1}) was recorded with application of untreated waste water as compared to other irrigation sources. However, it was on par with treatment receiving treated waste water (56.59 t ha^{-1}). Among fertilizer levels significantly higher fruit yield (68.81 t ha^{-1}) was recorded with application of 100 per cent RDF as compared to other fertilizer levels. Among interaction effect significantly higher fruit yield was recorded with application untreated wastewater along with application of 100 per cent RDF (73.30 t ha^{-1}) as compared to other treatment combinations. However, it was on par with application of treated wastewater along with application of 100 per cent RDF (71.88 t ha^{-1}).

Keywords: Domestic wastewater, Growth parameter, Yield parameter, Yield

Introduction

Water is a crucial input for agriculture around the globe. Recently most of the countries facing acute shortage of fresh water supply for crop production activities. Major precursors responsible for declining fresh water resources are increased population pressure, industrialization and cropping intensity (Ladwani *et al.,* 2012). It is estimated that, future global agricultural water consumption alone increase roughly by 19 per cent by 2050. In Indian context, agriculture sector alone accounts for more than 89 per cent of total waster use, as against eight per cent by domestic sector and three per cent by industrial sector (Paul *et al.,* 2010). In this context, use of wastewater in crop production is gaining importance as alternative sources of irrigation water. Wastewater contains appreciable amounts of macro and several micro nutrients required for plant growth. However, it also contains broad spectrum of contaminants which restricts its direct application to field. Therefore, proper treatment is necessary prior to field application to alleviate negative effects caused by hazardous contaminants.

Nutritional status of plant depends on the level of soil fertility status which decides the crop yield. It is well known fact that adequate fertilizer is required by tomato to realize potential yield and improved fruit quality. Continuous mining of nutrients by crop, leaching and other processes related to the natural dynamics of soil gradually decline the production capacity of soils resulted in lower yield levels. Therefore, maintaining adequate levels of nutrients in the soil is prerequisite for achieving higher yield and improved quality of produce. In view of inconsistent and inadequate results concerning the combination of these two management production practices a field research was framed to study the effect of different sources and fertilizer levels on growth, yield and yield parameters of tomato.

Material and methods

A field experiment was conducted at the Main Agricultural Research Station, Dharwad during *summer* season of 2014 and 2015. The soil of the experimental site was red sandy clay loam with a field capacity and wilting point of 26.63 and 13.21 per cent, respectively. The soil pH, electrical conductivity and organic carbon content of the experimental site were 7.26, 0.26 dS m^{-1} and 0.43 per cent, respectively. Similarly, initial available soil nitrogen, phosphorus and potassium of the experimental site were 250.88, 27.13 and 240.57 kg ha^{-1}, respectively.

The experiment was laid out in split-plot design with three replications. The main plots comprised of four sources of irrigation; Treated domestic wastewater (I_1), fresh water (I_2), domestic wastewater alternated with fresh water (I_3) and untreated domestic wastewater (I_4). Borewell water was used as a source of fresh water which served as control. Irrigation was scheduled when soil moisture content reached 30 per cent depletion of available soil water. Sub plots comprised of four fertilizer levels; 50 per cent of RDF (F_1), 75 per cent of RDF (F_2), 100 per cent RDF (F_3) and no fertilizer (F_4). The recommended doses of chemical fertilizer to tomato were 250:250:250 kg N, P_2O_5 and K_2O ha^{-1}, respectively and were applied in the form of urea, diammonium phosphate and muriate of potash as per the treatment details. With respect to F_1 and F_2 , 25 per cent of N and K_2O and 50 per cent of P_2O_5 were applied as basal dose and remaining quantity of N and K_2O was applied in three equal splits at 20-25 DAT, 40-45 DAT and 60-65 DAT (Days After Transplanting). Remaining 50 per cent of P_2O_5 was applied at 20-25 DAT. In case of F_3 , 50 per cent of N and 100 per cent of P_2O_5 and 100 per cent of K_2O were applied at the time of transplanting and remaining 50 per cent of N was top dressed at 4 weeks after transplanting. The entire tomato seedlings except in F_4 were treated with phosphorus solubilizing bacteria (PSB).

The tomato hybrid Abhilash from Monsanto Seminis Pvt. Limited was used for experiment. Twenty five days old seedlings were transplanted in the main field at 75 cm x 60 cm. Depth of irrigation provided at each irrigation was 5 cm. Total quantity of water and nutrients applied under different treatments is presented in Table 2 and 3.

Domestic wastewater treatment

Domestic wastewater generated in the University campus was used for experiment. It was treated using horizontal free flow constructed wetland using different filtering substrates and paragrass. Dimension of the constructed wetland was 29 m x 1 m x 0.3 m. It was constructed by excavating the soil and was divided into blocks of size 2 m x 1 m and 1 x 1 m alternatively. The blocks of 2 m x 1 m were filled with filtering substrates (boulders, pebbles, bricks, sand, charcoal etc.) and 1 m x 1 m were planted with paragrass as macrophytes.

The characteristics of different sources of irrigation water are presented in Table 1. Sewage effluent samples collected during cropping season were analyzed for physico-chemical properties according to Standard Methods (Anon., 1991). The data collected from the experiment was subjected to statistical analysis as described by Gomez and Gomez (1984).

Results and discussion

Effect on growth, yield and yield attributes of tomato

Growth and yield parameters differed significantly due to application of different sources of irrigation water and fertilizer levels. Among irrigation sources significantly higher plant height (68.27 cm), leaf area (75.77 cm^2), LAI (1.68) and dry matter production (76.72 g plant^{-1}) were noticed with application of untreated wastewater as compared to other irrigation sources (Table 4). However, plant height (64.69 cm), leaf area (73.16 cm^2), LAI (1.63) and dry matter production (65.92 g plant^{-1}) were found on par with treatment receiving treated domestic wastewater. Among fertilizer levels application of 100 per cent RDF (250:250:250 kg N, P_2O_5 and K_2O ha^{-1}) resulted in significantly higher plant height (70.83 cm), leaf area (81.71 cm^2), LAI (1.82) and dry matter production (91.91 g plant^{-1}) as compared to other fertilizer levels. Among interaction effect application of untreated wastewater along with 100 per cent RDF (250:250:250 kg N, P_2O_5 and K_2O ha^{-1}) recorded significantly higher plant height (77.93 cm), leaf area (91.57 cm^2), LAI (2.03)

Table 1. Characteristics of different sources of irrigation water used for experiment during 2014 and 2015 (mean ± standard deviation)

Sr. No	Parameters	Domestic wastewater		Treated wastewater		Fresh water (Borewell)	
		2014 (n=9)	2015 (n=10)	2014 (n=9)	2015 (n=10)	2014 (n=9)	2015 (n=10)
1	pH	7.39 ± 0.01	7.37 ± 0.02	7.41 ± 0.01	7.40 ± 0.02	7.53 ± 0.01	7.51 ± 0.01
2	EC (dS m^{-1})	1.22 ± 0.02	1.23 ± 0.01	1.18 ± 0.03	1.19 ± 0.01	0.73 ± 0.01	0.73 ± 0.01
3	Total solids (mg l^{-1})	1235.56 ± 147.91	1262 ± 117.54	882.22 ± 159.19	966 ± 115.87	-	-
4	TSS (mg l^{-1})	413.33 ± 40	442 ± 38.24	282.22 ± 48.41	326 ± 38.93	-	-
5	TDS (mg l^{-1})	822.22 ± 109.29	820 ± 122.93	600 ± 111.80	640 ± 117.37	-	-
6	BOD_5 (mg l^{-1})	348.65 ± 33.98	350.45 ± 22.18	260.81 ± 35.62	251.444 ± 19.39	-	-
7	COD (mg l^{-1})	498.42 ± 45.24	490.29 ± 45.38	377.25 ± 44.51	380.65 ± 44.57	-	-
8	NO_3-N (mg l^{-1})	2.58 ± 0.80	2.58 ± 0.88	2.04 ± 0.81	1.90 ± 0.84	1.12 ± 0.04	1.11 ± 0.03
9	NH_4-N (mg l^{-1})	14.56 ± 1.31	14.95 ± 1.54	12.69 ± 1.40	13.27 ± 1.69	0.56 ± 0.01	0.57 ± 0.01
10	Total N (mg l^{-1})	17.60 ± 1.28	17.53 ± 1.84	15.27 ± 1.25	15.18 ± 2.19	1.67 ± 0.05	1.65 ± 0.05
11	Total-P (mg l^{-1})	13.76 ± 0.43	13.82 ± 0.40	12.52 ± 0.45	12.45 ± 0.28	0.14 ± 0.01	0.13 ± 0.01
12	Total-K (meq l^{-1})	0.71 ± 0.10	0.75 ± 0.12	0.51 ± 0.09	0.52 ± 0.10	0.11 ± 0.005	0.11 ± 0.005
13	Ca (meq l^{-1})	6.27 ± 0.44	6.4 ± 0.43	5.20 ± 0.63	5.14 ± 0.57	2.60 ± 0.24	2.59 ± 0.23
14	Mg (meq l^{-1})	8.0 ± 0.59	8.04 ± 0.32	6.71 ± 0.43	7.34 ± 0.75	3.20 ± 0.17	3.21 ± 0.18
15	SO_4 (mg l^{-1})	6.21 ± 0.71	6.26 ± 0.44	5.71 ± 0.62	5.50 ± 0.37	0.37 ± 0.009	0.38 ± 0.017
16	Na (meq l^{-1})	6.09 ±0.35	6.19 ± 0.39	4.79 ± 0.36	4.94 ± 0.29	3.21 ± 0.06	3.13 ± 0.03
17	Chlorides (meq l^{-1})	6.36 ± 1.08	6.52 ± 0.92	5.38 ± 0.89	5.48 ± 0.78	2.44 ± 0.24	2.47± 0.24
18	Bicarbonates (meq l^{-1})	11.13 ± 1.88	11.48 ± 1.39	10.47 ± 1.97	10.66 ± 1.49	2.24 ± 0.19	2.26 ± 0.19
19	Fe (mg l^{-1})	1.14 ± 0.01	1.23 ± 0.02	0.91± 0.01	0.90 ± 0.01	0.19 ± 0.01	0.18 ± 0.02
20	Mn (mg l^{-1})	0.43 ± 0.05	0.40 ± 0.02	0.37 ± 0.04	0.37 ± 0.03	0.13 ± 0.01	0.14 ± 0.02
21	Zn (mg l^{-1})	0.45 ± 0.02	0.45 ± 0.04	0.39 ± 0.01	0.38 ± 0.02	0.17 ± 0.009	0.16 ± 0.01
22	Cu (mg l^{-1})	0.04 ± 0.01	0.05 ± 0.02	0.03 ± 0.09	0.03 ± 0.01	ND	ND

TSS: Total suspended solids; TDS: Total dissolved solids; BOD_5: Biological oxygen demand;
COD: Chemical oxygen demand; ND: Not detected

Table 2. Total quantity of water applied ($m^3\ ha^{-1}$) to tomato as influenced by different sources of irrigation water and fertilizer levels

Irrigation sources	2014-15					2015-16					Pooled				
	Fertilizer levels					Fertilizer levels					Fertilizer levels				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
I_1	7528 a	7618 a	7535 a	7585 a	7567 a	8680 a	8653 a	8631 a	8696 a	8665 a	8104 a	8136 a	8083 a	8141 a	8116 a
I_2	7574 a	7601 a	7566 a	7554 a	7574 a	8679 a	8702 a	8633 a	8651 a	8666 a	8126 a	8152 a	8099 a	8103 a	8120 a
I_3	7544 a	7564 a	7562 a	7677 a	7587 a	8678 a	8635 a	8687 a	8714 a	8679 a	8111 a	8099 a	8124 a	8196 a	8133 a
I_4	7598 a	7592 a	7578 a	7546 a	7579 a	8652 a	8687 a	8663 a	8616 a	8654 a	8125 a	8140 a	8120 a	8081 a	8116 a
Mean	7561 a	7594 a	7560 a	7591 a		8672 a	8669 a	8653 a	8669 a		8117 a	8132 a	8107 a	8130 a	
Sources		S.Em±		C.D. at 5%			S.Em±		C.D. at 5%			S.Em±		C.D. at 5%	
Irrigation sources (I)		20		70			16		56			8		29	
Fertilizer levels (F)		26		77			16		47			17		49	
I x F		53		154			32		94			34		99	

Main plot: Irrigation sources (I)
I_1: Treated domestic wastewater
I_2: Fresh water (borewell water)
I_3: Untreated domestic wastewater alternated with fresh water
I_4: Untreated domestic wastewater

Sub plot: Fertilizer levels (F)
F_1: 50% RDF (125: 125: 125 kg N, $P_2O_5,$ K_2O ha^{-1})
F_2: 75% RDF (187.5: 187.5: 187.5 kg N, $P_2O_5,$ K_2O ha^{-1})
F_3: 100% RDF (250:250:250 kg N, $P_2O_5K_2O$ ha^{-1})
F_4: Control (00:00:00 kg N, $P_2O_5,$ K_2O ha^{-1})

Table 3. Total quantity of nutrients (kg ha^{-1}) added to tomato through different sources of irrigation water during 2014 and 2015

	N	P	K	Ca	Mg	S	Fe	Zn	Mn	Cu										
Treatments	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
I_1F_1	107.50	115.35	88.14	94.67	139.33	154.21	364.25	390.84	282.01	2176.72	40.20	41.82	6.41	6.84	2.75	2.89	2.60	2.81	0.21	0.23
I_1F_2	108.88	114.70	89.27	94.14	141.30	153.34	369.41	388.64	286.01	2164.44	40.71	41.59	6.49	6.81	2.78	2.87	2.64	2.80	0.21	0.23
I_1F_3	107.61	115.25	88.23	94.58	139.65	154.07	365.11	390.49	282.68	2174.73	40.24	41.78	6.41	6.84	2.75	2.89	2.61	2.81	0.21	0.23
I_1F_4	108.38	116.86	88.86	95.91	141.57	156.22	370.12	395.95	286.56	2205.13	40.53	42.37	6.46	6.93	2.77	2.93	2.63	2.85	0.21	0.23
I_2F_1	11.90	12.83	0.99	0.99	30.45	32.77	184.53	197.87	136.27	956.42	2.62	2.90	1.35	1.38	1.20	1.22	0.92	1.07	0.00	0.00
I_2F_2	11.95	12.92	1.00	1.00	30.98	33.00	187.76	199.20	138.66	962.87	2.63	2.92	1.35	1.38	1.21	1.23	0.92	1.08	0.00	0.00
I_2F_3	11.89	12.62	0.99	0.98	30.23	32.23	183.21	194.57	135.30	940.47	2.62	2.85	1.34	1.35	1.20	1.20	0.92	1.05	0.00	0.00
I_2F_4	11.87	12.67	0.99	0.98	30.16	32.37	182.81	195.40	135.00	944.50	2.61	2.87	1.34	1.36	1.20	1.21	0.92	1.06	0.00	0.00
I_3F_1	67.84	85.06	48.89	56.08	112.36	133.00	312.00	349.82	236.37	1707.83	23.15	26.55	4.68	5.59	2.53	2.38	1.97	2.11	0.14	0.20
I_3F_2	68.07	85.83	49.06	56.83	113.56	134.41	315.16	352.21	238.76	1719.60	23.23	26.87	4.70	5.65	2.54	2.40	1.98	2.12	0.14	0.20
I_3F_3	68.22	82.61	49.19	54.56	113.72	129.17	315.08	338.95	238.72	1654.82	23.28	25.81	4.71	5.43	2.54	2.31	1.98	2.04	0.14	0.20
I_3F_4	68.45	86.23	49.24	57.03	112.66	135.05	312.74	354.50	236.93	1730.72	23.34	26.98	4.73	5.68	2.59	2.41	2.00	2.14	0.14	0.20
I_4F_1	125.14	133.68	97.84	104.79	195.69	221.79	443.11	485.29	339.23	2377.60	44.15	47.47	8.11	9.33	3.20	3.41	3.06	3.03	0.28	0.38
I_4F_2	125.03	134.62	97.75	105.53	197.54	223.35	447.29	488.71	342.43	2394.35	44.12	47.80	8.10	9.39	3.20	3.44	3.05	3.05	0.28	0.38
I_4F_3	124.78	136.07	97.56	106.66	196.29	225.75	444.47	493.94	340.26	2420.02	44.03	48.31	8.08	9.49	3.19	3.47	3.05	3.09	0.28	0.39
I_4F_4	124.22	135.13	97.12	105.92	194.84	224.19	441.19	490.53	337.75	2403.29	43.83	47.98	8.05	9.43	3.18	3.45	3.03	3.07	0.28	0.38

Main plot: Irrigation sources (I)
I_1: Treated domestic wastewater
I_2: Fresh water (borewell water)
I_3: Untreated domestic wastewater alternated with fresh water
I_4: Untreated domestic wastewater

Sub plot: Fertilizer levels (F)
F_1: 50% RDF (125: 125: 125 kg N, $P_2O_5,$ K_2O ha^{-1})
F_2: 75% RDF (187.5: 187.5: 187.5 kg N, $P_2O_5,$ K_2O ha^{-1})
F_3: 100% RDF (250:250:250 kg N, $P_2O_5K_2O$ ha^{-1})
F_4: Control (00:00:00 kg N, $P_2O_5,$ K_2O ha^{-1})

Table 4. Effect of treated and untreated domestic wastewater and fertilizer levels on growth attributes of tomato

Irrigation sources (I)	Plant height (cm)					Leaf area (cm^2)					Leaf area index (LAI)				
	Fertilizer levels (F)														
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
I_1	61.69 ef	67.58 cd	73.79 b	55.69 g	64.69 a	66.95 e	76.87 c	84.28 b	64.53 e	73.16 a	1.49 de	1.71 bc	1.87 ab	1.43 ef	1.63 a
I_2	52.69 gh	59.84 f	64.48 de	47.59 i	56.15 b	56.32 f	63.08 e	73.68 cd	43.66 g	59.19 b	1.25 fg	1.40 ef	1.64 cd	0.97 h	1.32 b
I_3	55.41 g	61.08 ef	67.12 cd	50.08 hi	58.42 b	65.23 e	67.11 e	77.33 c	48.83 g	64.62 b	1.45 e	1.49 de	1.72 bc	1.09 gh	1.44 b
I_4	64.47 de	70.72 bc	77.93 a	59.96 f	68.27 a	68.55 de	78.99 bc	91.57 a	63.96 e	75.77 a	1.52 de	1.76 bc	2.03 a	1.42 ef	1.68 a
Mean	58.57 c	64.81 b	70.83 a	53.33 d		64.26 c	71.51 b	81.71 a	55.24 d		1.43 c	1.59 b	1.82 a	1.23 d	
Sources	S.Em±			C.D. at 5%		S.Em±			C.D. at 5%		S.Em±			C.D. at 5%	
I	0.79			2.73		1.66			5.74		0.037			0.128	
F	0.59			1.72		1.06			3.08		0.023			0.069	
I x F	1.18			3.44		2.11			6.17		0.047			0.137	

Table 5. Effect of treated and untreated domestic wastewater and fertilizer levels on dry matter production and yield attributes of tomato

Irrigation sources (I)	Dry matter production (g $plant^{-1}$)					Number of fruits $plant^{-1}$					Average fruit weight (g)				
	Fertilizer levels (F)														
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
I_1	55.46 de	67.32 cd	93.04 ab	47.85 fg	65.92 ab	54.47 e-g	60.94 b-d	65.75 ab	48.41 h-j	57.39 a	77.00 ef	82.98 c	89.09 a	57.03 j	76.53 a
I_2	46.12 e	50.86 e	82.73 bc	37.99 g	54.42 b	52.68 f-h	59.35 c-e	62.83 a-c	43.73 j	54.65 a	68.65 h	75.63 f	79.74 d	48.33 l	68.09 b
I_3	49.37 e	58.95 de	85.84 b	42.19 fg	59.09 b	54.06 e-h	60.98 b-d	64.80a-c	46.66 ij	56.62 a	71.98 g	77.82 de	81.97 c	51.98 k	70.94 b
I_4	67.54 dc	79.01 bc	106.03 a	54.29 f	76.72 a	56.61 d-f	62.33 a-d	68.18 a	49.94 g-i	59.26 a	79.67 d	85.49 b	90.82 a	59.94 i	78.98 a
Mean	54.62 c	64.04 b	91.91 a	45.58 d		54.45 c	60.90 b	65.39 a	47.18 d		74.32 c	80.48 b	85.40 a	54.32 d	
Sources	S.Em±			C.D. at 5%		S.Em±			C.D. at 5%		S.Em±			C.D. at 5%	
I	4.09			NS		0.79			2.73		0.87			3.02	
F	2.5			NS		0.59			1.72		0.42			1.22	
I x F	5			NS		1.18			3.44		0.84			2.45	

and dry matter production (106.03 g $plant^{-1}$) as compared to other treatment combinations. However, LAI (1.87) and dry matter production (93.04 g $plant^{-1}$) were on par with treatment receiving treated wastewater along with application of 100 per cent RDF (250:250:250 kg N, P_2O_5 and K_2O ha^{-1}). Similar results were reported by Faizan *et al.* (2014)

Among irrigation sources significantly higher average fruit weight (78.98 g) and average fruit diameter (5.69 cm) were noticed with application of untreated wastewater as compared to other irrigation sources (Table 5 and 6) . However, it was on par with treatment receiving treated wastewater (76.53 g and 5.52 cm average fruit weight and average fruit diameter, respectively). Among fertilizer levels significantly higher number of fruits $plant^{-1}$ (65.39), average fruit weight (85.40 g) and average fruit diameter (5.80 cm) were noticed with application of 100 per cent RDF (250:250:250 kg N, P_2O_5 and K_2O ha^{-1}). Among interaction effect, higher number of fruits $plant^{-1}$ (68.18), average fruit weight (90.82 g) and average fruit diameter (6.05 cm) were recorded with combined application of untreated wastewater along with 100 per cent RDF. However number of fruits $plant^{-1}$ (65.75) and average fruit weight (89.09 g) were on par with application of treated wastewater along with 100 per cent RDF.

Fruit yield of tomato differed significantly due to different sources of irrigation and fertilizer levels. Among irrigation sources application of untreated wastewater recorded significantly higher fruit yield (58.20 t ha^{-1}) as compared to other irrigation sources. However it was on par with treatment receiving treated wastewater (56.59 t ha^{-1}). Application of 100 per cent RDF resulted in significantly higher fruit yield (68.81 t ha^{-1}) of tomato as compared to other fertilizer levels. Among interaction effect combined application of untreated wastewater along with 100 per cent recorded significantly higher fruit yield (73.30 t ha^{-1}) of tomato as compared to other treatment combinations (Table 5 and 6). However it was on par with treatment receiving treated wastewater in combination with application of 100 per cent RDF. The yield increase was mainly due to increased growth and yield attributes with higher leaf area and leaf area duration with waste water application and 100 per cent RDF. Such results were reported by Faizan *et al.* (2014).

Table 6. Effect of treated and untreated domestic wastewater and fertilizer levels on yield attributes and yield of tomato

Irrigation sources (I)	Fertilizer levels (F)									
	Average fruit diameter (cm)					Fruit yield (t ha^{-1})				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
I_1	5.47 gh	5.67 de	5.89 b	5.05 j	5.52 ab	52.72 c	61.19 b	71.88 a	40.57 f	56.59 a
I_2	5.14 j	5.38 hi	5.54 fg	4.61 l	5.17 c	46.53 de	54.49 c	64.18 b	30.87 g	49.02 b
I_3	5.32 i	5.55 e-g	5.72 cd	4.86 k	5.36 b	47.78 d	55.60 c	65.89 b	34.11 g	50.85 b
I_4	5.63 d-f	5.81 bc	6.05 a	5.28 i	5.69 a	53.88 c	62.66 b	73.30 a	42.96 ef	58.20 a
Mean	5.39 c	5.60 b	5.80 a	4.95 d		50.23 c	58.48 b	68.81 a	37.13 d	
Sources	S.Em±		C.D. at 5%			S.Em±		C.D. at 5%		
I	0.05		0.18			1.02		3.51		
F	0.02		0.06			0.75		2.19		
I x F	0.04		0.12			1.5		4.38		

Data with same letters did not differ significantly

Main plot: Irrigation sources (I)
I_1: Treated domestic wastewater
I_2: Fresh water (borewell water
I_3: Untreated domestic wastewater alternated with fresh water
I_4: Untreated domestic wastewater
Sub plot: Fertilizer levels (F)
F_1: 50% RDF (125: 125: 125 kg N, P_2O_5, K_2O ha^{-1})
F_2: 75% RDF (187.5: 187.5: 187.5 kg N, P_2O_5, K_2O ha^{-1})
F_3: 100% RDF (250:250:250 kg N, $P_2O_5K_2O$ ha^{-1})
F_4: Control (00:00:00 kg N, P_2O_5, K_2O ha^{-1})

Besides, significant increase in growth, yield and yield attributes of tomato with application of either untreated or treated domestic wastewater might be due to enhanced supply of nitrogen, phosphorous and potassium in the root rhizosphere that might have increased the uptake of nutrients and its further translocation from source to sink as evident from quantity of nutrients added through different irrigation sources (Table 3). In the present investigation, it was noticed that application of either untreated or treated domestic wastewater supplied adequate quantities of plant nutrients as compared to other irrigation sources (Table 3) and hence significant improvement in growth, yield and yield attributes of tomato were noticed under these treatments. Application of untreated or treated domestic wastewater not only met the water requirement of crop but also supplied considerable amount of nutrients (Table 2 and 3) at regular interval required for crop growth and development throught the crop growth period and ultimately resulted in higher fruit yield. Similar kind of results were reported by Sawalha *et al.* (2014), Mahadev *et al.* (2015), Cirelli *et al.* (2012) and Gatta *et al.* (2015). Similarly application of 100 per cent RDF might have increased the nutritional status of the soil and increased the available nutrients for plant uptake and ultimately resulted in higher growth and yield of crop. The significant increase in growth, yield and yield attributes with different doses fertilizer of under irrigation in tomato were reported by Feleafel and Mirdad (2013), Lawal *et al.* (2015), Ughade *et al*. (2015) and Oyewole *et al.* (2014).

Conclusion

Among sources of irrigation, application of untreated domestic wastewater resulted in significantly higher fruit yield, yield and growth attributes and was on par with treatment receiving treated domestic wastewater but both were superior over other irrigation sources. The increase in fruit yield was 16.39 and 14.53 per cent with application of untreated and treated domestic wastewater, respectively as compared to fresh water application. Among fertilizer levels, application of 100 per cent RDF resulted in significantly higher fruit yield, yield and growth attributes as compared to other fertilizer levels. The increase in fruit yield was 47.74 per cent with 100 per cent RDF as compared to absolute control. Interaction effects due to application of untreated domestic wastewater along with 100 per cent RDF recorded significantly higher fruit yield, yield and growth attributes and was on par with treatment receiving treated domestic wastewater along with 100 per cent RDF. The increase in fruit yield was 60.67 and 60.54 per cent with application of untreated and treated domestic wastewater along with 100 per cent RDF, respectively as compared to fresh water application without fertilizers.

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