Effect of quality of irrigation water and nitrogen levels applied through trickle irrigation on yield and water use efficiency of tomato under semi-arid environment

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ABSTRACT

A field experiment was conducted for two years to evaluate the effect of water quality, N levels and different methods of planting-cum-irrigation on yield and water use efficiency in tomato. The paired row sowing under trickle irrigation gave the highest fruit yield (kg/plant), which was accompanied by 50% saving of irrigation water under both the irrigation water qualities. Similarly, under trickle irrigation, 50% N applied produced same fruit yield as compared with 100% N under each furrow irrigation of ridge planted tomato under both water qualities. Poor quality irrigation water reduced the fruit yield significantly during first year, but reduction was non significant during second year of experimentation. The water use efficiency recorded was the highest in paired sown tomato under trickle irrigation.

Key words: Tomato, drip, irrigation methods, water quality.

INTRODUCTION

Water is the most important natural resource for agricultural development and economic advancement of any country. But it is a major constraint to crop production in the arid and semi-arid regions of the world. Traditional irrigation methods (furrow, border and flood irrigation) deliver water to plants through gravity but usually results in substantial water losses and limited uniformity in water distribution. Modern irrigation technologies, *i.e.* drip and sprinkler irrigation results in higher water use efficiency as compared to traditional methods. These modern technologies have opened up opportunities to cultivate soils with low water holding capacity (coarse textured soils) and steep slopes. These technologies have also enabled regions with limited water supplies to shift from low value crops having high water requirements (*e.g.* cereals) to high value crops having low water requirements (*e.g.* vegetables, fruits etc.). South-Western region of Punjab has light textured soils with brackish underground water and limited supply of canal water. The most of the tomato growing farmers' in this area apply irrigation through check-basin (flood irrigation) method. The wasteful and harmful system of flood irrigation practiced widely in South Asia must be replaced with furrow, drip or sub-irrigation systems as observed by Lal (3), and Buttar *et al.* (2). Dwindling supplies of good quality water for irrigation and increasing demand from other water users, the farmers are left with no option but to use saline-sodic underground water. Surface irrigation with poor quality waters usually leads to build up of salinity and sodicity problems and thus unsustainable crop yields. However, drip irrigation is the most effective method to apply water and nutrients directly to the plants, which saves water but also increases yields of vegetable crops as reported by Tiwari *et al.* (7). Sanchita *et al.* (5) also reported that drip irrigation at 100% evaporation replenishment throughout the crop season with cent per cent supplementation of recommended dose of N and K (75: 60 kg/ha) through emitters of 2 l/h discharge rate was found to be optimum for profitable cultivation of tomato with optimum quality and economic return. Similarly, Thind *et al.* (6) reported that in cotton, application of pre-sowing irrigation with canal water and all subsequent irrigations with poor quality water in alternate furrows improved the seed cotton yield significantly as compared to poor quality water application in flat sown crop. The present investigation was undertaken to study the effect of quality of water and N level under different methods of planting-cum-irrigation on the yield and water use efficiency of tomato.

MATERIALS AND METHODS

The field experiment was conducted at Research Farm of Punjab Agricultural University Regional Research Station, Bathinda, India for two years. The research farm is located at an altitude of 211 m above mean sea level and is intersected by 30°9' N latitude 74°56'E longitude. Geologically the farm

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Table 1. Physical and hydraulic properties of the soil profile of the experimental site.

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture	Bulk density (Mg m^{-3})	Hydraulic conductivity (mm h^{-1})
0-15	80.0	12.5	7.5	Loamy sand	1.58	8.7
15-30	92.5	5.0	2.5	Sand	1.58	39.3
30-45	81.3	10.0	8.8	Loamy sand	1.54	36.9
45-60	72.5	17.5	10.0	Silt	1.55	4.7
60-75	72.5	17.5	10.0	Silt	1.49	32.9
75-90	68.8	20.0	11.3	Silt	1.59	12.8
90-105	72.5	17.5	10.0	Silt	1.72	2.60
105-120	70.4	17.5	12.2	Silt	1.73	4.6
120-135	71.6	18.8	9.7	Silt	1.75	1.9
135-150	69.1	20.0	10.9	Silt	1.73	2.1
150-165	51.6	31.3	17.2	Silt	1.81	0.7
165-180	37.9	42.5	19.7	Silt	1.75	1.2

Table 2. Chemical properties of the soil profile of the experimental site.

Depth (cm)	pH	EC dS m^{-1}	OC (%)	NH_4-N, kg ha^{-1}	NO_3-N, kg ha^{-1}
0-15	8.8	0.366	0.420	17.65	23.52
15-30	8.9	0.284	0.315	11.76	31.36
30-45	8.7	0.311	0.120	7.84	29.41
45-60	8.5	0.332	0.150	15.68	39.20
60-75	8.5	0.229	0.105	5.89	27.44
75-90	8.8	0.303	0.090	3.92	27.44
90-105	8.8	0.297	0.405	15.68	31.36
105-120	8.7	0.379	0.240	7.84	43.12
120-135	8.5	0.372	0.210	11.76	47.04
135-150	8.6	0.369	0.210	3.92	31.36
150-165	8.7	0.342	0.150	0.20	35.28
165-180	8.7	0.310	0.075	0.20	45.09

area forms a part of the Indo-Gangetic alluvial plains. The physical, hydraulic and chemical properties of the soil profile of the experimental site are given in Tables 1 & 2. The details of experimental treatments are given in Table 3. The experiment was laid out in split plot design with two qualities of water, *i.e*. canal water and poor quality tube well water in main plots and seven irrigation methods with water rates and N combinations in sub plots with three replications. The irrigation water was applied on IW/CPE ratio of 1.0 in each furrow irrigation in ridge planted crop. The tomato variety TH 1 was transplanted in second week of February during both the years and experiment continued till June 22 and May 27 during first and second years, respectively. Whole of phosphorus (60 kg P_2O_5 ha^{-1}) was applied as basal dose (before sowing) in all the treatments. In each furrow (R_{EF}) and alternate furrow (R_{AF}) method, one third of recommended N (of the total 140 kg N ha^{-1}) was applied as basal, whereas second and third splits were applied at active vegetative growth and fruit setting stage, respectively. The electrical conductivity and residual sodium carbonate of the canal and tubewell water used was 0.5 and 2.2 dS m^{-1} and 0.6 and 6.4 meq l^{-1}, respectively. The drip irrigation system consisted of polyethylene laterals of 12 mm in diameter with in-line drippers at 45 cm distance. The drippers had a discharge rate of 2.46 l h^{-1} under

Table 3. Details of the experiment treatments.

Method of irrigation	Treatment designation	Method of sowing	Method of irrigation	% of water recorded	% relative water applied
Ridge, Each furrow irrigation	R_{EF}	Ridge	EF	100	100
Ridge, Alternate furrow irrigation	R_{AF}	Ridge	AF	100	70
Drip irrigation in normal sowing (75 cm spaced rows)	D_{NS}	Flat normal row	D_{ER}	100	100
Drip irrigation in dense paired row (40 × 60 × 40 cm)	D_{DPR}	Flat DPR	D_{PR}	100	75
Drip irrigation in paired row (40 × 110 × 40 cm)	D_{PR}	Flat PR	D_{PR}	100	50
Drip irrigation in normal sowing by application of 75 % of recommended nitrogen	$D_{NS\ 75}$	Flat normal row	D_{ER}	75	100
Drip irrigation in normal sowing by application of 50% of recommended nitrogen	$D_{NS\ 50}$	Flat normal row	D_{ER}	50	100

an operational pressure of 1.0 kg cm^{-2}. The irrigation in drip system was applied at 2-3 day intervals for required time to deliver the calculated quantity of water. In drip irrigation system, N was applied at 10-day intervals in 6 equal split doses starting from 10 days after transplanting. In 75 and 50% N of recommended dose treatments, N was reduced according to the requirement of the treatment. Water expense was calculated by adding irrigation water applied, seasonal effective rainfall and profile moisture used in each treatment. For computation of water expense efficiency (WEE), fresh fruit yield per hectare were divided by the water expense and expressed as kg ha^{-1} cm^{-1}.

The data revealed that tomato fruit yield responded differently to different quantities and qualities of water applied through furrow and drip irrigation system (Table 4). The influence of method of irrigation on fruit yield and quantity of irrigation applied is envisaged from the fact that in canal water irrigation applied through drip, yield increment of tomato to the tune of 8.6% was recorded in paired row (D_{PR}) over each furrow irrigation (R_{EF}) coupled with 50.0% saving in irrigation water applied. Similarly, the corresponding increase over alternate furrow irrigation was 9.4% with 30.0% saving in water. Ayars *et al.* (1) also reported that yield in drip irrigated tomato was higher than under furrow irrigation system. The quality of irrigation water significantly influenced the fruit yield which is evident from the fact that generally in poor quality irrigation, the mean fruit yield in absolute quantities was considerably reduced in comparison to canal water. Poor quality water applied through trickle irrigation in paired sowing yielded 19.1% higher than each furrow irrigation with 50% saving in irrigation water. Malash *et al.* (4) also reported that drip irrigation system would provide an advantages using saline water with more frequent irrigation to keep a high soil matric and low salt concentration in root zone. It is pertinent to mention here that in canal water, only 50% N applied through fertigation produced equivalent amount and even higher fresh fruit yield of tomato in comparison to ridge sown crop irrigated through each furrows (R_{EF}), respectively. The fertigation of tomato in canal irrigation system with 100, 75 and 50% of recommended N produced 8.6, 1.2 and 1.9% higher yield over each furrow irrigation method. Paired row sowing (D_{PR}) in drip with 100% recommended dose of N in good quality canal water and poor quality tube well water conditions gave 2.2, 11.6%; and 7.6, 9.8% higher fruit yield over D_{NS} and D_{DPR}, respectively. It may be concluded that in canal water irrigation, half of the recommended dose of N applied through drip in normal sown crop produced equivalent amount of fruit yield in comparison to each furrow irrigation with 100% recommended N. The mean amount of water applied was minimum (33.4 cm) in D_{DPR} and maximum (66.7 cm) in each of the D_{NS}, D_{NS50}, and D_{NS75} treatments. The mean total water expense varied from 55.2 to 91.8 cm and 55.8 to 90.5 cm for all the irrigation methods under canal and tube well water supplies, respectively. The highest and lowest water expense efficiency was recorded with drip irrigation in dense paired row sowing (D_{DPR}) with 100% recommended dose of N and through drip with 50% recommended dose of N (D_{NS50}) under both the qualities of water. It may be concluded that either 50% water or 50% N can be saved under trickle irrigation without any yield reduction in tomato.

Table 4. Tomato fruit yield (q ha^{-1}), irrigation water applied, water expense and water expense efficiency as influenced by quality of water, methods of irrigation and nitrogen rates.

Irrigation method	Canal water (CW)			Tube well water (TW)		
	I^{st} yr	II^{nd} yr	Mean	I^{st} yr	II^{nd} yr	Mean
Fresh fruit yield (q ha^{-1})						
R_{EF}	204	309	256	154	276	215
R_{AF}	213	296	254	173	280	226
D_{NS}	224	320	272	178	299	238
D_{DPR}	204	294	249	176	293	234
D_{PR}	238	318	278	203	310	256
$D_{NS\ 75}$	216	303	259	165	281	223
$D_{NS\ 50}$	205	318	261	162	258	210
Mean	215	308		173	285	
LSD (p = 0.05)						
Water quality			10.4			NS
Irrigation method			7.3			27.8
Interaction			10.3			NS
Irrigation water applied (cm)						
R_{EF}	71.5	60.5	66.0	71.5	60.5	66.0
R_{AF}	52.0	44.0	48.0	52.0	44.0	48.0
D_{NS}	72.5	60.8	66.7	72.5	60.8	66.7
D_{DPR}	54.4	45.6	50.0	54.4	45.6	50.0
D_{PR}	36.3	30.4	33.4	36.3	30.4	33.4
$D_{NS\ 75}$	72.5	60.8	66.7	72.5	60.8	66.7
$D_{NS\ 50}$	72.5	60.8	66.7	72.5	60.8	66.7
Mean	61.7	51.8		61.7	51.8	
Water expense (cm)						
R_{EF}	86.2	85.2	85.7	85.1	82.9	84.0
R_{AF}	67.2	69.1	68.2	68.4	74.0	71.2
D_{NS}	89.0	92.8	90.9	83.2	93.9	88.6
D_{DPR}	70.4	79.1	74.7	72.7	74.3	73.5
D_{PR}	50.0	60.4	55.2	51.3	60.3	55.8
$D_{NS\ 75}$	89.1	94.5	91.8	86.9	87.0	86.9
$D_{NS\ 50}$	88.6	92.2	90.4	89.8	91.1	90.5
Mean	77.2	81.9		76.8	80.5	
Water expense efficiency (kg $ha^{-1}cm^{-1}$)						
R_{EF}	237	363	300	181	333	257
R_{AF}	317	428	372	253	378	315
D_{NS}	252	345	298	214	318	266
D_{DPR}	289	371	330	242	394	318
D_{PR}	476	526	501	395	514	454
$D_{NS\ 75}$	242	321	281	190	323	256
$D_{NS\ 50}$	231	345	288	180	283	231
Mean	289	384		234	362	

REFERENCES

1. Ayars, J.E., Schoneman, R.A., Dale, F., Meso, B. and Shouse, P. 2001. Managing subsurface drip irrigation in the presence of shallow ground water. *Agric. Water Mgt.* **47**: 243-64.

2. Buttar, G.S., Thind, H.S. and Aujla, M.S. 2006. Methods of planting and irrigation at various levels of nitrogen affect the seed yield and water use efficiency in transplanted oilseed rape (*Brassica napus* L.). *Agric. Water Mgt.* **85**: 253-60.

3. Lal, R. 2000. Soil management in the developing countries. *Soil Sci.* **165**: 57-72.

4. Malash, N., Flowers, T.J. and Ragab, R. 2005. Effect of irrigation systems and water management practices using saline and non-saline water on tomato production. *Agric. Water Mgt.* **47**: 243-64.

5. Sanchita, B., Borbora, P.D., Pankaj, B. and Luchon, S. 2010. Effect of drip-fertigation on performance of tomato under Assam conditions. *Indian J. Hort.* **67**: 56-60.

6. Thind, H.S., Buttar, G.S. and Aujla, M.S. 2010. Yield and water use efficiency of wheat and cotton under alternate furrow and check-basin irrigation with canal and tubewell water in Punjab, India. *Irrig. Sci*. **28**: 489-96.

7. Tiwari, K.N., Mal, P.K., Singh, R.M. and Chattopadhyay, A. 1998. Response of okra (*Abelmoschus esculentus* L.) to drip irrigation under mulch and non-mulch conditions. *Agric. Water Mgt.* **38**: 91-102.

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