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Production and Economics of Hybrid Tomato (*Solanum lycopersicum*) under Drip Fertigation

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Abstract: A field study was conducted at experimental farm of Interfaculty Department of Irrigation Water Management, Post Graduate Institute, M.P.K.V., Rahuri, Maharashtra, India during *Rabi* season of 2014-15. The experiment was laid out in randomized block design with eight treatments and three replications. The treatments consisted of four levels of recommended does (RD) of fertilizer application as 100%, 75%, 75% with foliar sprays and 50% recommended dose under drip fertigation (DF) compared with conventional irrigation and conventional fertilizer application. The significantly higher yield (52.62 t ha^{-1}) of tomato was obtained in DF with 100% RD and it was at par with DF with 75% RD + 3 foliar sprays, DF with 100% RD, N and K drip, P through soil and DF with 75% RD. The drip method had lowest water use (458.4 mm) as compared with 878.6 mm in surface irrigation method. The treatment consisting DF with 100% RD provided net seasonal income (Rs. 3,93,311 ha^{-1}), net extra income over control (Rs.1,52,056 ha^{-1}). The maximum B:C ratio (3.96) was observed in drip irrigation (DI) with 100% RD, N and K drip, P through soil followed by DF with 100% RD. The fertigation with 75% RD in 18 weekly splits as per schedule is the best treatment for improved growth, yield and water productivity of tomato (*var*. Abhinav) cultivated in silty clay loam soils of Western Maharashtra.

Keywords: *Drip fertigation, tomato productivity, water soluble fertilizers, water use*

Introduction

Tomato is one of the most popular vegetables not only in India but it also commercially important vegetable of the world . It is cultivated in almost all parts of India and occupy an area of about 8.82 lakh hectares with production of about 187.35 lakh tonnes. In Maharashtra, tomato is cultivated in an area of about 0.5 lakh hectares with production of 12 million tonnes, with an average productivity of 24 t ha^{-1}. (Anonymous 2015).Tomato responds well to irrigation and its yield can be increased through improved irrigation technique like drip irrigation. It saves water and fertilizer to large extent (Singandhupe *et al.* 2005). Jena *et al.*(2017) reported 25 per cent fertilizer saving with 43.5 per centincrease in yield under fertigation over surface irrigation with conventional fertilizer applied through soil. Considering the water saving upto 50 per cent, approximately double area can be irrigated under drip (Dalvi *et al.* 1999). Tomato also responds well to additional fertilizer applied and it is reported to be a heavy feeder of NPK particularly hybrid varieties. The fertilizers applied in water soluble form become easily available with crop demand for maximumutilization of nutrients which results in higher productivity (Boyhan *et al.* 2001). Higher tomato yield and fertilizer use efficiency through drip fertigation has been reported (Shyamaa *et al.* 2009). Earlier studies in tomato

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demonstrated a yield increase of 16 per cent with drip irrigation over furrow method when 60 per cent of the N and K fertilizers were injected than when all were applied at planting (Mahajan and Singh 2006). The water soluble fertilizers have proved their superiority over conventional fertilizers by increasing both water and fertilizer use efficiency under fertigation but they are costly from economic point of view. With the increasing prices of fertilizers it has become necessary to explore the impact of drip fertigation on production and economics of hybrid tomato under drip fertigation.

Materials and Methods

A field experiment was conducted at experimental Farm of M.P.K.V., Rahuri, Ahmednagar, during *Rabi* season of 2014-2015. Agro-climatically, the area falls under the scarcity zone of Maharashtra with annual rainfall of 520 mm which is mostly erratic and uncertain in nature. The soil was silty clay loam in texture and alkaline in reaction (pH 7.9). The available nitrogen, phosphorus and potassium were 151.0, 17.10, 257.0 kg ha^{-1} respectively. The soil was well drained with moisture content at field capacity and permanent wilting point was 36.10and 17.10 respectively. The experiment was laid out in randomized block design with eight treatments and three replications. The treatment consisted of T_1- drip fertigation (DF)with100% recommended dose (RD) of fertilizer (300:150:150N:P_2O_5:K_2O kg ha^{-1}); T_2- DF with 75% RD;T_3- DF with 75%RD+ 2% foliar sprays of 17:44:00 at 30,45 and 60 DAT; T_4 -DF with 50%RD; T_5 -drip irrigation (DI) with 100%RD of nitrogen and potassium applied through drip (N and K-drip), and phosphorous through soil (P-soil);T_6- DI with no fertilizer; T_7- DI with 100% RD through conventional fertilizer (CF) and T_8- surface irrigation (SI) with 100% RD through CF. In fertigation treatments (T_1 to T_5), the fertilizers were applied in 18 splits apportioned as per crop growth stages (Table1). In N and K fertigation treatment (T_5), the entire N and K was applied through urea and muriate of potash (MOP) in 18 weekly splits as per schedule and P was applied as a basal dose through soil.

The 21 days old tomato seedling *cv*. Abhinav was planted during 1st week of December and was harvested during last week of April 2015. Planting was done on single row of 1.05 m and plant spacing of 0.45m. Adequate plant protection measures were adopted as and when required. In drip irrigation system, single lateral of 16 mm per four rows of tomato with 4 inline drippers at 0.45m was provided. In conventional method of irrigation, 63 mm depth of irrigation was applied at 50 mm cumulative pan evaporation. In drip method, the water requirement was calculated using reference evapo-transpiration and crop coefficients (Allen *et al.*1998). In conventional practice of fertilizer application (T_7 and T_8), 50% RD of N, full dose of P and K was applied as basal dose and remaining 50% N was applied at 30 days after transplanting (DAT). The fertigation was done using water soluble fertilizers *viz.* urea (46:0:0), urea Phosphate (17:44:00) and MOP (0:0:60) through automized fertijet system (Galicolmake, Isreal) at weekly interval.

Table 1. Fertigation schedule for tomato (Proportion of nutrients to be applied in 18 weekly splits)

Days after transplanting	Nitrogen (N)		Phosphorus (P)		Potassium (K)	
	%	Kg	%	Kg	%	Kg
1-28 (4 weeks)	15	45	20	30	15	22.5
29-56 (4 weeks)	40	120	35	52.5	30	45
57-84 (4weeks)	30	90	35	52.5	35	52.5
85-126 (6weeks)	15	45	10	15	20	30
Total	100	300	100	150	100	150

The total cost of cultivation was calculated as cost of cultivation plus the fixed cost on irrigation systems. Net seasonal income was the returns from fruit yield, and total net income was net seasonal returns plus returns from additional area that can be brought under irrigation due to water saving in drip. Benefit:cost ratio was calculated for each treatment by using following equation.

$$\text{Benefit: cost ratio} = \frac{\text{Gross income (Rs. ha}^{-1})}{\text{Total cost of cultivation (Rs. ha}^{-1})}$$

The net extra income over control (Rs. ha-mm) as influenced by different treatments were calculated by subtracting the corresponding value of the net seasonal income from the value of net seasonal income of control treatment. The water productivity (Rs. ha-mm) as influenced by different treatment was calculated by division of corresponding values of the net seasonal income with water used (Pawar *et al*. 2013). The statistical analysis was performed by using analysis of variance (ANOVA) for randomized block design as per Panse and Sukhatme (1985)

Results and Discussion

Growth contributing characters

All the biometric characters were found to be maximum in drip irrigated treatments as compared to conventional method of irrigation (Table 2).The DF with 100% RD(T_1) recorded significantly maximum plant height (93.53 cm) however, it was at par with treatment T_3(92.00 cm), T_2(91.67 cm) and T_5 (90.87 cm) at 90DAT and significantly superior over other treatments. The treatment comprising of DI with no fertilizer application had lowest plant height (81.93 cm). Higher plant height in T_1 might be due to fertigation at proper growth stages and efficient use of the water soluble fertilizers in 18 weekly splits rather than conventional fertilizers applied as a basal dose (Table 2). The significantly highest plant height in the pressurized irrigation methods might be due to availability of sufficient moisture in root zone of the crop at different growth stages. Dukre (1991) also opined similar views.

Table 2. Growth contributing characters of tomato as influenced by different treatments

Sr. No.	Treatments	Plant height (cm)	No.of branches plant^{-1}	Leaf area (dm^2)
1	T_1(DF with 100% RD)	93.53	10.6	25.12
2	T_2(DF with 75% RD)	91.67	9.63	23.80
3	T_3(DF with 75% RD+ foliar sprays)	92.00	9.77	24.63
4	T_4(DF with 50% RD)	85.67	8.10	22.82
5	T_5(DI with 100%RD of CF) (N & K- drip, P- soil)	90.87	9.70	24.20
6	T_6(DI with no fertilizer)	81.93	7.50	22.50
7	T_7(DIwith100% RD through CF)	85.00	8.51	23.20
8	T_8(SI with 100% RD through CF	87.33	8.80	23.00
	SE±	1.80	0.37	0.42
	CD at 5 %	5.46	1.10	1.27

DI= Drip Irrigation CF= Conventional Fertilizer SI=Surface Irrigation

The significantly maximum number of branches per plant (10.6) was recorded in DF with 100% RD (T_1) than other treatments owing to application of fertilizers in 18 splits as per crop growth stages and availability of sufficient moisture in the root zone of the crop. Ezuddin *et al.* (1986) reported significant increase in number of branches per plant of tomato with the increasing levels of NPK. The significantly higher leaf area (25.12 dm^2) was recorded in DF with 100% RD treatment than other treatments at 90 DAT. However, it was at par with treatment having DF with 75% RD + foliar sprays (T_3, 24.63 dm^2) and DI with 100% RD of CF,

N&K-drip and P-soil (T_5, 24.20 dm^2). This might be due to effect of fertigation at proper growth stagesanduseof the water soluble fertilizers rather than conventional fertilizers. Maher (1991) reported maximum leaf area in drip irrigation than surface irrigation system in garlic crop. The minimum leaf area (22.50 dm^2) was recorded in no fertilizer treatments followed by SI with 100% RD of CF .

Yield contributing characters

The number of fruits per plant was found to be significantly influenced by fertigation treatments (Table 3). The significantly higher number of fruits per plant(54.2) was recorded in DF with 100% RD, however, it was at par with T_3 (52.4), T_5 (50.6) and T_2 (50.5). DI with no fertilizer treatment (T_6, 38.1) recorded the minimum number of fruits per plant(41.2) followed by surface irrigation with 100% RD of CF. The number of fruits increased with the increase in level of fertilizers. These results are in agreement Hegde and Srinivas (1989).

The data (Table3) indicated that the treatment having DF with 100% RD had significantly maximum average weight of fruits per plant (2.66 kg) but it was at par with treatment T_3 (2.33 kg), T_2 (2.31 kg) and T_5 (2.21 kg). Mahajan and Singh (2006) reported increase in yield due to fertigation as compared to conventional method of irrigation and fertilizer application. The minimum weight of fruits per plant (1.19 kg) was observed in DI with no fertilizer followed by surface irrigation with 100% RD of CF .

Tomato yield

The yield of tomato per hactre was significantly influenced by fertigation treatments (Table3).The significantly highest yield of tomato fruit (52.62 t ha^{-1}) was observed in treatment of DF with 100% RD and it was at par with T_3 (49.27 t ha^{-1}), T_5(48.62 t ha^{-1}) and T_2 (48.30 t ha^{-1}). DI with no fertilizer treatment (T_6) showed lowest yield of tomato. The yield under T_2 (DF with 75%RD) produced significantly higher tomato yield (48.30 t ha^{-1}) than SI with100% RD of CF (35.6 t ha^{-1}) and thus indicated that fertigation technique can save fertilizers upto 25%. The increase in yield in drip irrigated and fertigated treatments were mainly due to better and adequate supply of water and nutrients at the right time and at right place. Similar results of higher yield under fertigation as compared with conventional methods of fertilizer application was reported by Pan *et al.(*1999) and Jena *et al.* (2017).

Table 3. Yield contributing characters of tomato plant by different treatments

Sr. No.	Treatments	No. of fruits plant^{-1}	Wt. of fruits plant^{-1} (kg)	Yield (t ha^{-1})
1	T_1 (DF with 100% RD)	54.2	2.66	52.62
2	T_2 (DF with 75% RD)	50.5	2.31	48.30
3	T_3(DF with 75% RD + foliar sprays)	52.4	2.33	49.27
4	T_4(DF with 50% RD)	40.2	1.64	34.62
5	T_5(DI with 100 % RD of CF) (N & K- drip, P- soil)	50.6	2.21	48.62
6	T_6(DI with no fertilizer)	38.1	1.19	25.11
7	T_7(DI with 100% RD through CF)	42.4	1.68	41.49
8	T_8(SI with 100% RD through CF)	41.2	1.66	35.60
	SE+-	1.32	0.16	2.11
	CD at 5 %	4.00	0.48	6.33

Water use

The drip method recorded lowest water use of 458.4 mm as compared to 878.6mm in surface method (Table 4) and thus saved water to the extent of 49.51%. The treatment DF with 100% RD resulted into 47.8 per cent increase in yield with 49.51 per cent water saving

over surface irrigation with CF. In drip, the water is applied directly in root zone which increases water application efficiency and decreases the water loss through percolation, infiltration and evaporation thereby saving large quantity of water. The maximum water use efficiency (WUE) of 114.8 kg ha-mm was recorded in DF with 100% RD due to higher yield, whereas minimum values of WUE (40.5 kg ha-mm) was obtained in SI with 100% RD through CF followed by T_6. Wadatkar *et al. (*2002) reported similar findings in onion crop.

Table 4. Water applied and water use efficiency in different water saving and % increase in yield of tomato

Sr. No.	Treatments	Total water applied (mm)	WUE (kg ha-mm)	Water saving (%)	% increase yield over T_8
1	T_1(DF with 100% RD)	458.4	114.8	49.51	47.80
2	T_2(DF with 75% RD)	458.4	105.4	49.51	35.67
3	T_3(DF with 75% RD+ foliar sprays)	458.4	107.5	49.51	38.39
4	T_4 (DF with 50% RD)	458.4	75.5	49.51	-2.75
5	T_5 (DI with 100 % RD of CF) (N & K- drip, P- soil)	458.4	106.1	49.51	36.57
6	T_6(DI with no fertilizer)	458.4	54.8	49.51	-
7	T_7(DI with 100% RD through CF)	458.4	90.5	49.51	16.54
8	T_8(SI with 100% RD through CF)	878.6	40.5	0.0	0.0

Economics

The net seasonal income, benefit cost ratio, total net seasonal income, net extra income over surface irrigation and water productivity as influenced by different treatments was presented in table 5. The seasonal cost of drip system was calculated for 1.05 x 0.45 m single row planting of tomato (6 months crop period). Relatively higher cost of cultivation was estimated in fertigation treatments because of higher market cost of water soluble fertilizer. The higher cost of cultivation (Rs. 1,22,125 ha-mm) was recorded in treatment T_1. The seasonal cost of surface irrigation treatment (Rs.1,10,956) was slightly lower than drip with conventional fertilizer (Rs.1,11,396).

Table 5. Economics of tomato as influenced by different treatments

Sr. No.	Treatments	Cost of cultivation (Rs ha^{-1})	Net seasonal income (Rs ha^{-1})	Total net income (Rs ha^{-1})	B:C ratio	Net extra income over control (Rs ha^{-1})	Water productivity (Rs ha^{-1} mm)
1	T_1(DF with 100% RD)	122125	393311	753847	3.93	152056	1148
2	T_2(DF with 75% RD)	114992	356344	682993	3.81	115089	1058
3	T_3(DF with 75% RD+ foliar sprays)	117709	363327	696377	3.83	122072	1075
4	T_4(DF with 50% RD)	107920	226616	434348	2.90	-14639	756
5	T_5(DI with 100 % RD of CF) (N & K- drip, P- soil)	111059	363477	696665	3.96	116957	1060
6	T_6(DI with no fertilizer)	90008	149428	286404	2.47	-91827	548
7	T_7(DI with 100% RD through CF)	110956	292280	560204	3.38	51025	905
8	T_8(SI with 100% RD through CF)	111396	241255	241255	3.10	0.0	405

Net seasonal income and B:C ratio

Maximum net seasonal income Rs.3,93,311 was recorded in DF with 100%RD treatment due to higher fruit yield followed by DF with 75%RD + foliar spray treatment (Rs.3,63,327). Treatment T_6 gave lowest yield of fruit hence the net seasonal income was also lowest as Rs. 1,49,428 at the rate Rs.10,000 t^{-1} for the crop. Maximum of B:C ratio (3.96) was recorded in treatment T_5 followed by T_1 (3.93). The fertigation using water soluble fertilizer recorded relatively lower B:C ratio due to high market price of water soluble fertilizers. The minimum B:C (2.47) was observed in no fertilizer treatments and highest net seasonal income of Rs.2,38,402 ha-mm, total net income of Rs.5,68,958 and net extra income over control (Rs.86,656) under 100% RD of fertigation treatment.

Total net income

The drip irrigation resulted into 49.51 per cent water saving over conventional method of irrigation. Thus, it can bring 0.92 ha additional area under irrigation. The total net income calculated taking into consideration of the additional area that can be brought under irrigation due to water saving in drip was found to the extent of Rs.7,53,847 in treatment T_1followed by T_5(Rs.6,96,665).

Net extra income over control

The net extra income over control was highest in DF with 100% RD treatment (Rs. 1,52,056) followed by DF with 75%RD + foliar spray treatment (Rs. 1,22,072) and T_5 (Rs. 1,16,957). The lowest value of net extra income over control was recorded in treatment T_6. All fertigation treatments gave higher income than conventional fertilizer application treatment.

Water productivity

The net income per unit of water got improved considerably to Rs.1148 per ha-mm in drip irrigation method as compared to Rs.405 per ha-mm in surface method of irrigation. The maximum water productivity was recorded in DF with 100% RD (Rs.1148 ha-mm) followed by T_3 (Rs.1075ha-mm)whereas, conventional method of irrigation treatment(T_8) had minimum water productivity of Rs. 405ha-mm.

Conclusions

The water soluble fertilizer resulted into higher growth and yield of tomato. The 100% RD of drip fertigation brought better growth and yield contributing characters. The application of water soluble fertilizers through drip resulted into 25 per cent saving in fertilizer. The drip used lowest water and thus resulted into 49.51 per cent water saving and also increase in yield. The application of 100% RD through drip fertigation resulted into maximum net seasonal income (Rs.3,93,311), total net income (Rs.7,53,847), net extra income over control (Rs.1,52,056) and maximum water productivity of Rs.1148 ha-mm. It can be concluded that 75% RD through drip fertigation 18 weekly splits as per growth stages was the best treatment for improved growth, yield and water productivity of tomato (*var*. Abhinav) cultivated in silty clay loam soils of western Maharashtra.

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