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EFFECT OF DRIP FERTIGATION ON YIELD, WATER USE AND ECONOMICS OF HYBRID TOMATO CULTIVATED IN INCEPTISOLS

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ABSTRACT

The research trial was conducted under field conditions to study the effect of water soluble fertilizers through drip on yield of tomato, water use and economics during 2015-16 at Interfaculty Department of Irrigation Water Management, MPKV Rahuri. The experiment was conducted by using a randomized block design with eight treatments replicated three times. The treatment comprised of $\mathbf{T_1}$ - DI with 100% fertigation, $\mathbf{T_2}$ - DI with 75% fertigation, $\mathbf{T_3}$ - DI with 75% fertigation + 3 foliar sprays, $\mathbf{T_4}$ – DI with 50% fertigation, $\mathbf{T_5}$ – DI with 100% RDF (N and K through drip, P through soil), $\mathbf{T_6}$ - No fertilizer under drip irrigation, $\mathbf{T_7}$ – DI with 100% RD through CF and $\mathbf{T_8}$ – SI with 100% RD through CF. In all fertigation treatments, fertilizers were applied in 18 splits at weekly interval. The result indicated that T_1 produced significantly more yield (79.29 t ha^{-1}) than all other treatments. T_3 recorded significantly maximum yield over T_8. It indicated that fertigation using water soluble fertilizer can save fertilizer dose up to 25 % with increased yield. The total seasonal water requirement in drip method was 505.9 mm compared with 1037.2 mm in surface irrigation and resulted in to 51.22% water saving. Higher cost of cultivation was observed in drip irrigation and fertigation treatments than conventional irrigation treatments due to the cost of irrigation systems and higher costs of WSF. Treatment T_1 (DI with 100 % fertigation) gave highest net seasonal income, total net income, Net extra income over surface and water productivity and whereas, T_5 gives higher B:C ratio. Treatment T_8 (100 % CF under SI) gave lowest values of all economical parameters than other treatments.

Keywords:
Drip irrigation, Conventional fertilizer, Recommended dose, Fertigation, Tomato, Yield, water use and economics

INTRODUCTION

Tomato (*Solanum lycopersicum L.*) is one of the most widely grown vegetable in India and belongs to the family Solanaceae. It is cultivated in almost all parts of India and occupying an area of about 8.82 lakh hectares with production of about 187.35 Lakh Tones. It is grown in Uttar Pradesh, Orissa, Andhra Pradesh, Maharashtra, Madhya Pradesh and Assam (Choudhary *and Kundal* 2015). In Maharashtra tomato is cultivated in area of about 0.5 lakh hectares with production of 12 Million Tones, with average productivity 24 MT ha^{-1} (Anonymous, 2015). Pan *et al*., 1999 reported in the comparison of conventional drip irrigation and fertilization with drip fertigation, the

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fertigated tomatoes produced a red fruit yield of 72 t ha^{-1} while those under conventional irrigation and fertilization yielded only 44 t ha^{-1}. Fruit yield was significantly increased in drip irrigation by 12.5% as compared to furrow irrigation (Singandhupe *et. al.,* 2002). The methods of nutrient application play an important role in supplying the nutrients to the plants because the efficacy of fertilizer applied in soil being low due to various losses and fixations of nutrients (Ya-dan *et al.*, 2017). Foliar nutrition is designed to eliminate the above problems particularly with respect to macro nutrients. Tomato responds well to the application of fertilizers and is reported to be a heavy feeder of NPK. Efficient use of fertilizer and water is highly critical to sustained agricultural production. Fertilizers applied under traditional methods are generally not utilized efficiently by the crop.

Fertigation is technique of supplying dissolved nutrients to crops through an irrigation system. It allows frequent, uniform and precise application of nutrients through drip directly into the zone of maximum root activity as per need of crop which results into higher yield fertilizer saving, higher Fertilizer use efficiency with over conventional method of fertilizer application (Shaymaa *et al.*, 2009 and Pawar *et al.*, 2013b). Different fertigation intervals to tomato crop proved superior over surface irrigation with straight fertilizers by recording maximum values of all growth attributing characters (Pawar *et al*., 2013a). The present investigation was undertaken to study the effect of water soluble fertilizer on yield, water use and economics of tomato over conventional method of irrigation and fertigation.

MATERIALS AND METHODS

The field experiment was conducted during 2015-2016 at research farm of Inter Faculty Department of Irrigation Water Management, Mahatma Phule Krishi Vidyapeeth, Rahuri. Agroclimatically, the area falls under semi-arid and sub-tropical zone of Maharashtra with annual rainfall of 520 mm which is mostly erratic and uncertain in nature (Dastane 1972). The experimental plot was uniform and leveled with well drained, medium black soil alkaline in nature with pH 8.0. The soil texture was silty clay loam with 20.78% of coarse sand, 15.21% of fine sand, 38.84% of silt and 23.97% of clay. The bulk density of soil was 1.32 Mg m^{-3} and electrical conductivity was 0.30 dS m^{-1}. The initial status soil was low in available N (153.00 kg ha^{-1}), medium in available P (17.10 kg ha^{-1}) and high in available K (256.00 kg ha^{-1}). The field experiment was laid out in randomized block design (RBD) with eight treatments replicated thrice. The treatment details were as follows: $\mathbf{T_1}$ - DI with 100% fertigation, $\mathbf{T_2}$ - DI with 75% fertigation, $\mathbf{T_3}$ - DI with 75% fertigation + 3 foliar sprays, $\mathbf{T_4}$ – DI with 50% fertigation, $\mathbf{T_5}$ – DI with 100% RDF (N and K through drip, P through soil), $\mathbf{T_6}$ - No fertilizer under drip irrigation, $\mathbf{T_7}$ – DI with 100% RD through CF and $\mathbf{T_8}$ – SI with 100% RD through CF. The recommended dose of fertilizer for tomato was 300:150:150 N: P_2O_5:K_2O kg ha^{-1}. In treatment T_5, full dose of phosphorus was applied as basal dose and N and K was applied through drip as per schedule. In treatment T_7 and T_8, 50 % nitrogen and 100 % dose of phosphorus and potassium was applied as a basal dose and 50 % nitrogen was applied in 3 splits of 20 days interval after transplanting. Foliar sprays of 2 per cent urea phosphate (17:44:0) was given to T_3 at 30, 45 and 60 days after transplanting.

Table 1- Fertilizer schedules for tomato

Proportion of nutrients applied in 18 weekly splits

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

The tomato seedlings (variety Abhinav) of 21 days old were transplanted on 22 Dec. 2015 with spacing of

1.05 x 0.45 m. The statistical analysis was performed by using analysis of variance (ANOVA) for randomized block design as Panse and Sukhatme, 1967. The net quantity of water requirement emitter^{-1} at every alternate day was calculated by following formula (Allen *et al.*, 1998).

$$V = ETc \times S1 \times S2 \times Wa$$

Where, V, Volume of water per two days in litters; S1, spacing between dripper (m); S2, Spacing between laterals (m); Wa, Wetted area.

The total cost of cultivation was worked out by adding the system cost and operational cost of respective treatment. Net seasonal income was worked out by subtracting the cost of production from the gross returns for each treatment. The total net income (₹ ha-1) as influenced by different treatments where additional area was considered and calculated by adding the corresponding value of the seasonal net income and additional net income.

Benefit: cost ratio was calculated for each treatment by using following equation.

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

Net extra income over control (₹ ha^{-1}) 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^{-1}mm^{-1}) as influenced by different treatment was calculated by division of corresponding values of the net seasonal income with water used (Pawar *et al*. 2013b)

RESULTS AND DISCUSSIONS

Yield and yield contributing characters

The data regarding yield of tomato in tones ha^{-1} was found to be influenced significantly by fertigation treatments (Table 1). The treatment T_1 recorded significantly higher yield (79.29 t ha^{-1}) as compared to other treatments. However, it was at par with T_5 (76.25 t ha^{-1}), T_3 (75.74 t ha^{-1}), and T_2 (74.35 t ha^{-1}). The tomato yield obtained under T_3 was 75.74 t ha^{-1} which was significantly superior over T_8 (52.40 t ha^{-1}). The minimum yield of 33.50 t ha^{-1} was observed in treatment T_6. It indicated that fertigation using WSF can save fertilizer dose up to 25 % with increase in yield up to 41.8 per cent. These results are in close conformation with Pan *et al.,* (1999) and Mahajan and Singh (2006), Rumpel (2003), Pawar *et al*. (2013 a) Maher (1991) and Mane *et al*. (2015) observed that increase in yield was recorded due to fertigation when compared with conventional method of fertilizer application.

Fertigation through drip dominated over the conventional fertilizer application treatments in regards to number of fruits plant^{-1}. The significantly higher number of fruits plant^{-1} were recorded in T_1 (77.52), however, it was at par with T_5 (74.70), T_3 (72.22) and T_2 (71.66). T_1 registered maximum average weight of fruits plant^{-1} (3.75 kg) but it was at par with treatment T5 (3.58 kg plant^{-1}), T_3 (3.55 kg plant^{-1}) and T_2, (3.51 kg plant^{-1}) and the lowest weight of fruits plant^{-1} was observed in T_6 (1.41 kg plant^{-1}). Yield and its contributing characters improved in drip irrigation treatments as compared to surface irrigation with conventional fertilizer through soil. This might be due to more availability of nutrients under drip than that of straight fertilizer application through soil in surface irrigation.

Water use

The conventional method of irrigation used maximum amount of water (1037.2 mm) as compared to drip irrigation (505.9 mm). Hence, saving of water to the extent of 51.22% was possible due to drip irrigation method with 13.29% increase yield in conventional fertilizer with drip irrigation. In DI with 100% WSF (T_1) recorded 48.5% increase in yield over surface irrigation with 51.22% water saving. The maximum water use efficiency of 156.7 kg ha^{-1} mm recorded in DI with 100% WSF and lowest WUE of 51.5 kg ha^{-1} mm in SI with 100% CF.

Economics

The data regarding the cost of cultivation, net seasonal income, total net income, B:C ratio and net extra

Table 2- Yield (t ha^{-1}) of tomato as influenced by different treatments.

Tr. No.	Treatments	No. of fruits plant^{-1}	Wt. of fruits plant^{-1} (kg)	Yield (t ha^{-1})
T_1	DI with 100 % WSF	77.52	3.75	79.29
T_2	DI with 75 % WSF	71.66	3.51	74.35
T_3	DI with 75 % WSF+3 FS	72.22	3.55	75.74
T_4	DI with 50 % WSF	52.54	2.53	53.10
T_5	DI with 100 % (NKTD, PS)	74.70	3.58	76.25
T_6	DI with no fertilizer	46.96	1.41	33.50
T_7	DI with 100 % + CF	56.21	3.00	60.50
T_8	SI with 100 % + CF	53.24	2.47	52.40
	SE $\pm$	2.99	0.08	2.20
	CD at 5 %	9.07	0.25	6.69

Table 3- Water use by tomato as influenced by different treatments.

Tr. No.	Treatments	Total water applied (mm)	WUE kg ha^{-1} mm	Water saving (%)	(%) Increase in yield over surface
T_1	DI with 100 % WSF	505.9	156.7	51.22	48.5
T_2	DI with 75 % WSF	505.9	146.9	51.22	39.2
T_3	DI with 75 % WSF + 3 FS	505.9	149.7	51.22	41.8
T_4	DI with 50 % WSF	505.9	104.9	51.22	--
T_5	DI with 100 % (NKTD, PS)	505.9	150.7	51.22	42.78
T_6	DI with no fertilizer	505.9	66.2	51.22	--
T_7	DI with 100 % CF	505.9	119.6	51.22	13.29
T_8	SI with 100 % CF	1037.2	51.5	….	0.00

Table 4- Economics of tomato as influenced by different treatments

Tr. No.	Seasonal cost of cultivation (₹ ha^{-1})	Net seasonal income (₹ha^{-1})	Total net income (₹)	B:C ratio	Net extra income over control (T_8) (₹)	Net profit mm^{-1} of water (₹)
T_1	127739	268731	550899	3.10	114899	531
T_2	120608	251126	514808	3.08	97294	496
T_3	122388	256306	525428	3.09	102474	507
T_4	113533	151967	311533	2.34	-	300
T_5	115737	265513	544302	3.29	111681	525
T_6	99361	68139	139686	1.69	-	135
T_7	115737	168763	382865	2.61	32931	369
T_8	108035	153965	153965	2.43	0	148
	SE $\pm$	12302	24561	0.11	11822	23.68
	CD at 5 %	37314	74498	0.32	35857	71.82

income over control of tomato as influenced by different fertigation treatments are presented in Table 3.

Cost of cultivation.

The seasonal cost of drip irrigation (₹11663.72) treatments observed higher than surface irrigated treatment due to higher cost of installation of drip systems. Result showed that the higher cost of cultivation in WSF than CF because higher market cost of WSF. The highest cost of cultivation was observed in treatment T_1 (₹ 1,27,739) followed by T_3 (₹ 1,22,388) and lowest cost of cultivation was observed in T_6 (₹ 99,361) as the cost water soluble fertilizers was more than of conventional fertilizers.

Net seasonal income

The data regarding the net seasonal income indicated maximum value (₹ 2,68,731) per ha in treatment T_1 due to the higher fruit yield followed by treatment T_5 (₹ 2,65,513). Treatment T_6 gave lowest yield of fruit hence the net seasonal income was also lowest as (₹ 68,139) and rate of tomato was ₹ 5,000 ton^{-1} for all treatments (Table 3). fertigation gave more net seasonal income than conventional fertilizer application treatment. These results are in close conformity with the results of Pawar *et al.* (2013b).

Total net income

The additional area (1.05 ha) that can be brought under irrigation due to water saving by drip irrigation was taken into consideration while determining the total net income. Drip irrigation with 100 % fertigation (T_1) recorded highest total net income of ₹ 5,50,899 as compared to surface irrigation with CF ₹ 1,53,965 which was at par with T_5 (₹ 5,44,302), T_3 (₹ 5,25,428) and T_2 (₹ 5,14,808). It was highest in T_1 due to increased fruit yield. The lowest value ₹ 1,39,686 was observed in treatment T_6 (DI with no fertilizer).

B:C ratio

The B:C ratio was improved under fertigation treatments as compared to surface irrigation with CF. All treatments recorded B:C ratio between 1.69 to 3.29. Maximum B:C ratio was recorded in treatment T_5 (NK fertigation, P through soil) *i.e.* 3.29. However, it was at par with T_1 (3.10), T_3 (3.09) and T_2 (3.08). The lower B:C ratio (1.69) was observed in T_6.

Net extra income over control

The net extra income over control was highest in treatment T_1 (₹ 1,14,899). However, it was at par with T_5 (₹ 1,11,681), T_3 (₹ 1,02,474) and T_2 (₹ 97,294). The lowest value of net extra income over control was recorded in treatment T_7 (₹ 32,931). All fertigation treatments gave more net extra income over control than conventional fertilizer application treatment.

Water productivity

The maximum value of water productivity was recorded in T_1 (100 % RD of fertigation) i.e. 531 ₹ ha^{-1} mm^{-1} water used. However, it was at par with T_5 (525 ₹ ha^{-1} mm^{-1}), T_3 (507 ₹ ha^{-1} mm^{-1}) and T_2 (496 ₹ ha^{-1} mm^{-1}). The minimum water productivity was recorded for T_6 i.e. 135 ₹ ha^{-1} mm^{-1} water used.

Conclusions

The significantly maximum yield of tomato was obtained in treatment T_1 over other treatments. However, it was at par with T_5, T_3 and T_2. The drip irrigation with 100 % fertigation resulted into 48.5 % increase in yield with 51.22 % water saving as compared to surface irrigation. The DI with 100% fertigation recorded significantly higher net seasonal income, total net income, net extra income over surface and net profit mm^{-1} of water (₹ 531) as compared surface irrigation with CF and other treatments. However, T_5 recorded highest B:C ratio 3.29. However, it was at par with T_1, T_3 and T_2.

On the basis of the results obtained, it can be concluded that drip irrigation with 75 % RD of fertigation in 18 splits at weekly interval (Table 1) is necessary for achieving higher yield, maximum monetary benefits and water productivity of tomato (var. Abhinav) under silty clay loam soils of western Maharashtra.

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