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Short communication

Production of hybrid tomato for higher income under drip irrigation and fertigation in Kashmir valley

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Water management is one of the key factors in successful cultivation of vegetable crops and tomato responds well to irrigation regime. Flood irrigation as the conventional method is being widely used to irrigate most of the vegetable crops particularly tomato grown in India. However, research studies carried out in India and abroad have reported higher application efficiency of drip irrigation over conventional (surface) method of irrigation by optimizing the use of limited water. Drip irrigation is one of the efficient irrigation system. It is the concept where water is applied at low rate frequently near the root zone of the plant. Drip irrigation is also ideally suited for controlling the placement and supply rate of water soluble fertilizers though fertigation. The sufficient fertilizer application and convenient irrigation techniques are very important factors affecting the growth and yield of tomato.

Drip irrigation can be very effectively utilized in Kashmir situations. Moreover, with a declining water table due to the excessive use of ground level water, Kashmir stands as a perfect case for the adoption of water management techniques at the earliest. In this context, the present experiment was conducted to study the performance of tomato hybrid SH-TH-1 under drip irrigation and fertigation system for water and fertilizer saving; and growth and yield benefits in comparison with conventional (surface) method of irrigation and fertilizer application. The economic analysis of adopting drip irrigation system in tomato under Kashmir conditions was also studied.

The experiment was conducted during *kharif* 2007-08 at the experimental farm of Division of Olericulture, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar, Srinagar (J&K). The experiment was laid out in randomized block design (factorial) and replicated four times with sixteen treatment combinations. The treatments include four levels of irrigation *viz.,* 100%, 80% & 60% ET through drip and recommended flood irrigation; and four levels of fertilizers *viz.,* 100, 80 & 60% recommended NPK through fertigation and 100% recommended NPK through manual (150: 90: 60 kg/ha). Surface irrigation and manual fertilizers application were treated as control. The volume of water required under drip irrigation system was computed using following equation: V = [DE x CF x AA x PC]/IE.

Where, V = Volume of water required (lit/plant/day), DE = Daily Pan Evaporation (mm), CF = Crop factor, AA = Area allotted per plant (m^2), PC = Pan coefficient and IE = Irrigation efficiency as a decimal. The crop factor (CF) is related to relative water demand to crop growth stages and CF value for tomato was taken as 0.4, 0.7, 1.1 and 0.9 for initial stage, development stage, mid-season and during late-season stage, respectively according to the Doornbos *et al*. (4). The average pan evaporation 4.43 mm/day and total rainfall 210.4 mm were recorded during whole cropping period of the experiment. The pan factor value was 0.75 as suggested for USDA class A pan. The area allotted per plant was 0.24 m^2.

Twenty-five day-old seedlings of tomato hybrid SH-TH-1 were transplanted on 17th May, 2007 with 3 rows per plot at the spacing of 60 cm × 40 cm comprising total 27 plants per plot. The drip system was laid out parallel to the crop rows and each lateral with emitter distance at 40 cm and 2.2 lph discharge rate served by each emitter. The amount of water actually applied by way of drip irrigation system was based on climatological approach. Irrigation was scheduled on alternate days in case of drip irrigation whereas surface irrigation was given according to the locally adopted frequency. Fertigation with recommended fertilizers dose, *i.e.* 150:90:60 kg NPK/ha was given according to the treatments in 10 split doses at 10 days interval beginning 10 days after transplanting. However, in case of manually fertilized plots, half dose of nitrogen (urea) and full doses of phosphorus (SSP) and potassium (MOP) were applied as basal dose while, the remaining half dose of nitrogen was applied in two spits at 30 and 45 days after transplanting as top dressing. All other packages of practices were adopted as recommended for the region. Observations were recorded for various growth, yield and its attributes. Volumetric method was used for calculating the uniformity coefficients of drip irrigation system (Raina *et al*., 9) and it was found

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93.5%. For economic analysis, total cost of production (fixed and operating costs of drip irrigation system) under different drip irrigation and fertigation treatments was estimated (Imtiaz *et al*., 6).

The results revealed that drip irrigation and fertigation exhibited a significant effect on various growth and yield attributes of tomato hybrid SH-TH-1 (Table 1). Among the irrigation levels, 80% ET through drip (I_2) produced maximum plant height (130.1 cm), number of primary branches per plant (8.35), number of nodes per main stem (29.8), number of fruits per plot (1455), average fruit weight (49.79) and yield (893.51 q/ha) whereas, the minimum values for these characters were recorded with surface irrigation (I_4). Increased yield under drip irrigation might have resulted due to better water utilization and easy uptake by plants. Similar results in tomato were reported by Sivanappan (12), and Singh and Kumar (11).

In case of fertigation levels, 60% recommended NPK through fertigation (F_3) recorded maximum plant height (132.4 cm), number of primary branches per plant (8.20), number of nodes per main stem (29.2), number of fruits per plot (1456), average fruit weight (48.4 g) and yield (865.74 q/ha) (Table 2). The appropriate and sufficient fertilizers application through fertigation makes it possible to match crop nutrient requirement at various growth stages with minimum leaching beyond the root zone resulting in improved growth and yield characteristics. Similar findings in tomato were also reported by Badra and Yazied (1), and Singandhupe (10).

Results indicated that the combined effect of drip irrigation and fertigation proved always superior over their individual effects (Table 3). The treatment combination of 80% ET through drip + 60% recommended NPK through fertigation recorded maximum values for growth and yield attributing characters and also produced the maximum fruit yield of 989.3 q/ha, which was found 81.6% higher than the traditional method of surface irrigation and fertilizer application (544.5 q/ha). The better performance and increased yield of tomato under drip irrigation and fertigation might be attributed to better water utilization and higher uptake of nutrients (Bafna *et al*., 2). These findings are in accordance with the earlier findings of Bhella (3) who observed 70% higher tomato yield under

Table 1. Effect of different levels of drip irrigation on growth, yield and its attributes of tomato.

Treatment	Plant height (cm)	No. of primary branches/ plant	No. of nodes/ main stem	No. of fruits/ plot	Fruit length (cm)	Fruit diameter (cm)	Pericarp thickness (cm)	Average fruit weight (g)	Fruit weight/ weight/ (kg)	Yield (q/ha)
I_1	123.4	7.66	27.9	1389.2	4.30	4.35	0.43	46.4	51.0	787.03
I_2	130.1	8.35	29.8	1455.1	4.35	4.57	0.42	49.7	57.9	893.51
I_3	125.5	8.00	28.8	1406.3	4.35	4.56	0.41	44.2	48.2	743.82
I_4	120.5	7.45	26.2	1293.7	4.25	4.26	0.39	40.0	42.6	657.40
CD at 5%	3.1	0.9	1.7	89.3	0.1	0.1	0.0	2.4	2.9	45.5

I_1 = 100% ET through drip irrigation; I_2 = 80% ET through drip irrigation; I_3 = 60% ET through drip irrigation; I_4 = 100% Surface irrigation.

Table 2. Effect of different levels of fertigation on growth, yield and its attributes of tomato.

Treatment	Plant height (cm)	No. of primary branches/ plant	No. of nodes/ main stem	No. of fruits/ plot	Fruit length (cm)	Fruit dia (cm)	Pericarp thickness (cm)	Average fruit weight (g)	Fruit yield/ plant (kg)	Yield (q/ha)
F_1	123.1	7.82	27.9	1372	4.27	4.38	0.43	44.7	48.7	751.54
F_2	128.8	7.95	28.6	1418	4.39	4.50	0.42	45.3	52.1	804.01
F_3	132.4	8.20	29.2	1456	4.43	4.59	0.40	48.4	56.1	865.74
F_4	115.2	7.48	26.9	1297	4.16	4.27	0.39	42.0	42.9	662.03
CD at 5%	3.1	0.9	1.7	89.3	0.1	0.1	0.0	2.4	2.9	45.5

F_1 = 100% RFD through fertigation; F_2 = 80% RFD through fertigation; F_3 = 60% RFD through fertigation; F_4 = 100% RFD through manual application.

drip irrigation and fertigation as compared to surface irrigation.

Greater reductions in water requirement of tomato were observed with drip irrigation levels over surface irrigation (Table 4). Drip irrigation at 100% ET consumed 24.80 cm water, 80% ET through drip consumed 19.84 cm water and 60% ET through drip consumed 14.88 cm water through out the cropping season as compared to 35.79 cm water in surface irrigation, thereby saving irrigation water to the tune of 30.7, 44.5 and 58.4% over surface irrigation. Similar benefit of water saving in tomato up to 44% was reported by Parikh *et al*. (8). Our findings are in accordance with the findings of Singh and Kumar (11), and Gupta *et al.* (5).

Fertilizer application through drip irrigation (fertigation) reduces fertilizer usage and minimizes ground water pollution by reducing fertilizer leaching due to excessive irrigation. Fertigation with 60% recommended NPK saved 40% fertilizers compared to traditional method of fertilizers application besides producing improved growth and maximum fruit yield. This could be attributed to the fact that the fertilizer application through fertigation device is restricted to the wetted volume of soil where the active roots were concentrated and hence was available to plants fully. Parikh *et al*. (8) reported that in vegetable crops, fertigation leads not only saving in fertilizer application but also prevents leaching losses. The cost of drip system at the present market rates (M/s Jain Irrigation Ltd., Jalgaon) was worked out for one hectare. The economic analysis of different treatments of drip irrigation and fertigation in tomato hybrid SH-TH-1 under Kashmir conditions is presented in Table 5. It is seen from the table that a net seasonal income of Rs. 3,79,931/- could be generated as against Rs. 1,81,706/- per hectare realized under normal surface irrigation system. The benefit: cost ratio for drip irrigation was found maximum (3.31**:**1) with 80% ET though drip + 60% recommended NPK through fertigation (I_2F_3). These calculations and findings confirm the earlier findings of Jadhav *et al*. (7), and Singh and Kumar (11).

Thus, it can be concluded that drip irrigation at 80% ET along with 60% recommended NPK through fertigation could be recommended on the basis of greater yield benefits, water and fertilizer saving, highest total net income and benefit cost ratio in tomato for Kashmir valley.

Table 3. Interaction effect of drip irrigation and fertigation on growth, yield and its attributes of tomato.

Treatment	Plant height (cm)	No. of primary branches/ plant	No. of nodes/ main stem	No. of fruits/ plot	Fruit length (cm)	Fruit dia. (cm)	Pericarp thickness (cm)	Average fruit weight (g)	Fruit yield/ plant (kg)	Yield (q/ha)
I_1F_1	121.0	7.70	27.3	1377.5	4.25	4.28	0.45	42.21	51.25	791.2
I_1F_2	128.2	7.75	28.7	1403.5	4.39	4.43	0.44	45.35	54.94	847.8
I_1F_3	129.5	7.95	29.0	1450.0	4.45	4.55	0.41	48.51	55.87	862.1
I_1F_4	115.0	7.25	26.6	1326.0	4.13	4.18	0.43	40.92	42.27	652.3
I_2F_1	130.7	8.35	29.8	1441.0	4.28	4.45	0.44	49.76	54.42	839.8
I_2F_2	133.2	8.50	29.9	1478.7	4.45	4.68	0.43	50.56	59.96	925.3
I_2F_3	138.7	8.65	30.6	1490.0	4.48	4.75	0.40	53.00	64.11	989.3
I_2F_4	118.0	7.90	28.8	1411.0	4.23	4.40	0.41	45.84	53.40	824.0
I_3F_1	123.7	7.90	28.9	1383.0	4.38	4.58	0.44	43.21	45.93	708.7
I_3F_2	129.0	7.95	29.2	1413.7	4.41	4.60	0.43	45.14	49.67	766.5
I_3F_3	133.0	8.40	29.9	1475.2	4.43	4.65	0.41	46.54	53.93	832.2
I_3F_4	116.5	7.75	27.3	1353.2	4.23	4.43	0.38	42.18	43.56	672.2
I_4F_1	117.2	7.35	25.8	1287.2	4.20	4.23	0.42	38.96	43.28	667.9
I_4F_2	124.7	7.60	26.6	1378.0	4.33	4.30	0.41	40.54	44.11	680.7
I_4F_3	128.5	7.80	27.5	1411.5	4.38	4.45	0.39	45.78	50.49	779.1
I_4F_4	111.5	7.05	25.0	1098.2	4.10	4.10	0.35	35.12	35.28	544.4
CD at 5%	6.34	1.93	3.57	178.72	0.21	0.30	0.04	4.90	5.90	91.03

I_1 = 100% ET through drip irrigation; I_2 = 80% ET through drip irrigation; I_3 = 60% ET through drip irrigation; I_4 = 100% Surface irrigation.

F_1 = 100% RFD through fertigation; F_2 = 80% RFD through fertigation; F_3 = 60% RFD through fertigation; F_4 = 100% RFD through manual application.

Table 4. Effect of drip irrigation and fertigation on yield enhancement, water and fertilizer saving in tomato.

Treatment combination	Yield (q/ha)	Increase in yield (%)	Water applied (cm)	Water saving (%)	Fertilizer applied (NPK kg/ha)	Fertilizer saving (%)
I_1F_1	791.2	45.3	24.80	30.7	150:90:60	-
I_1F_2	847.8	55.7	24.80	30.7	120:72:48	20
I_1F_3	862.1	58.3	24.80	30.7	90:54:36	40
I_1F_4	652.3	19.7	24.80	30.7	150:90:60	-
I_2F_1	839.8	54.2	19.84	44.5	150:90:60	-
I_2F_2	925.3	69.9	19.84	44.5	120:72:48	20
I_2F_3	989.3	81.6	19.84	44.5	90:54:36	40
I_2F_4	824.0	51.3	19.84	44.5	150:90:60	-
I_3F_1	708.7	30.1	14.88	58.4	150:90:60	-
I_3F_2	766.5	40.7	14.88	58.4	120:72:48	20
I_3F_3	832.2	52.8	14.88	58.4	90:54:36	40
I_3F_4	672.2	23.4	14.88	58.4	150:90:60	-
I_4F_1	667.9	22.6	35.79	-	150:90:60	-
I_4F_2	680.7	25.0	35.79	-	120:72:48	20
I_4F_3	779.1	43.0	35.79	-	90:54:36	40
I_4F_4	544.5	-	35.79	-	150:90:60	-

Table 5. Cost economics of different drip irrigation and fertigation treatments in tomato.

Treatment combination	Cost of fertilizer & their application (Rs./ha)	Cost of cultivation excluding fertilizer (Rs./ha)	Total cost of cultivation excluding system (Rs./ha)	Total seasonal cost of cultivation (Rs./ha) cost	Yield (q/ha)	Seasonal income from produce (Rs./ha)	Net seasonal income (Rs./ha)	Benefit : cost ratio (B:C ratio)
I_1F_1	10,937.35	74,237.05	85,174.40	119,093.90	791.2	395,600	276,506	2.32
I_1F_2	8,749.88	74,237.05	82,986.93	116,906.43	847.8	423,900	306,994	2.62
I_1F_3	6,562.41	74,237.05	80,799.46	114,718.96	862.1	431,050	316,331	2.75
I_1F_4	8,347.35	74,237.05	82,584.40	116,503.90	652.3	326,150	209,646	1.79
I_2F_1	10,937.35	74,237.05	85,174.40	119,093.90	839.8	419,900	300,806	2.52
I_2F_2	8,749.88	74,237.05	82,986.93	116,906.43	925.3	462,650	345,744	2.95
I_2F_3	65,62.41	74,237.05	80,799.46	114,718.96	989.3	494,650	379,931	3.31
I_2F_4	8,347.35	74,237.05	82,584.40	116,503.90	824.0	412,000	295,496	2.53
I_3F_1	10,937.35	74,237.05	85,174.40	119,093.90	708.7	354,350	235,256	1.97
I_3F_2	8,749.88	74,237.05	82,986.93	116,906.43	766.5	383,250	266,344	2.27
I_3F_3	6,562.41	74,237.05	80,799.46	114,718.96	832.2	416,100	301,381	2.62
I_3F_4	8,347.35	74,237.05	82,584.40	116,503.90	672.2	336,100	219,596	1.88
I_4F_1	10,937.35	82,196.44	93,133.79	127,053.29	667.9	333,950	206,897	1.62
I_4F_2	8,749.88	82,196.44	90,946.32	124,865.82	680.7	340,350	215,484	1.72
I_4F_3	6,562.41	82,196.44	88,758.85	122,678.35	779.1	389,550	266,872	2.17
I_4F_4	8,347.35	82,196.44	90,543.79	90,543.79	544.5	272,250	181,706	2.00

System installation cost = Rs. 3,39196; Seasonal system cost = Rs. 3,3919.5; Sale rate of tomato was Rs. 500/q.

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