

STUDIES ON INFLUENCE OF EMITTER DISCHARGE RATE, IRRIGATION SUPPLIES AND PLANTING PATTERN ON TOMATO IN HEAVY SOILS OF CENTRAL INDIA

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ABSTRACT. Field experiments were conducted during two post rainy seasons at J.N. Krishi Vishwa Vidyalaya, Jabalpur, India, to evaluate the effect of emitter discharge rate, drip irrigation supplies and planting pattern on soil moisture distribution patterns and yield of tomato in heavy soils. In the experiments during 1998, irrigation was applied through emitters ($2, 4 \text{ lhr}^{-1}$) and micro-tubes (6 lhr^{-1}) to conventional and paired-row plantings of tomato (var. ACC - 99). While, in the experiments during 2000, four irrigation supply levels (0.6, 0.8, 1.0, 1.2 times crop evapo-transpiration) combined with paired-row, four-row plantings of tomato (var. Pusa ruby) were applied. Observations revealed that fulfillment of 100 per cent of tomato crop evapo-transpiration need utilizing micro-irrigation (micro-tubes of rated discharge - 6 lhr^{-1}) combined with four-row plantings of tomato achieved a cost saving of 35.21 per cent on initial investment with significant gain in yield over paired-row planting in the heavy soils of central India.

Key words: Drip irrigation; Discharge rate; Irrigation supplies; Planting pattern.

INTRODUCTION

Drip irrigation represents one of the fastest expanding technologies in modern irrigated agriculture. With its high water use efficiency, it has great potential to boost crop productivity. Economic considerations usually limit the use of drip system to orchards and vegetables. The main items of expenditure in drip system, particularly for vegetable crops are the cost of lateral lines and number of emitters. Nevertheless, these high cost components can possibly be reduced by manipulation in crop planting pattern without significantly affecting the yield (Satpute and Pandey, 1989;

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Hapse *et al*, 1992; Goyal, 1993; Shinde 1996).

In drip irrigation the water movement and its distribution in the soil depends upon many parameters like soil type, crop cultivars, crop planting pattern, discharge rate of emitters, amount of water applied, and climatic factors, etc. While planning drip irrigation system for a crop it is imperative to select: (i) emitters of size that discharge water at a desired rate, (ii) irrigation supplies that render a wetted soil-volume sufficient to fulfill plant's evaporative demands and (iii) a planting pattern that reduces the cost of initial investment without adversely affecting crop yield. However, not much information is available on the influence of the combination of factors like emitter discharge rate, amount of irrigation supply, crop planting pattern and agro-environmental conditions on soil moisture distribution and its subsequent effect on crop yield in the heavy soils of central India.

In view of the above, two field experiments were conducted at J. N. Krishi Vishwa Vidyalaya, Jabalpur, during post-rainy seasons (January to May) of 1998 and 2000 respectively. In the Ist experiment (1998) effect of drip discharge-rate on soil moisture distribution under conventional, paired-row planting patterns of ACC-99 variety of tomato (*Lycopersicum esculentum*) was studied. On the basis of findings of I st experiment, II nd experiment (year 2000) was carried out with the objective to study the influence of irrigation supplies under

paired-row, four-row plantings (of Pusa ruby variety of tomato) on soil moisture distribution and tomato yield.

MATERIALS AND METHOD

Characteristics of the study area.

Experiments were conducted during post-rainy seasons of the years 1998 and 2000 at the 'Instructional Farm' of College of Agricultural Engineering, J.N. Krishi Vishwa Vidyalaya, Jabalpur, India. Jabalpur is situated at 23°09' N Latitude and 79°57' E Longitude with an altitude of 393m above mean sea level. Dry summer and cold winter characterize the climate of Jabalpur. Soil of the study area is clay overlaid with a thin layer of clay-loam and has an average bulk density of 1.95 g cc⁻¹, field capacity and wilting point are 40 per cent and 16 per cent respectively on dry weight basis, infiltration capacity is 0.67 cm hr⁻¹ (Jain and Saxena, 1996; Tripathi, 1998).

Experiment I. To study the effect of emitter discharge rate and planting pattern on soil moisture distribution and tomato yield in heavy soils. The experiment was carried during January to May, 1998 period.

The treatments were laid with under conventional and paired-row planting. Three emitter discharge rates viz. 2 lhr⁻¹ online emitter, 4 lhr⁻¹ online emitter, and 6 lhr⁻¹ micro-tube were used in the study. Row-to-row distance was fixed as 60 cm under conventional planting and 40 cm under paired-row planting. Thus, there were six treatment combinations based on planting pattern and type of emitter. These were: T₁ - (2 lhr⁻¹ on-line emitters under conventional planting), T₂ - (2 lhr⁻¹ on-line emitters under paired-row planting), T₃ - (4 lhr⁻¹ on-line emitters under conventional planting), T₄ - (4 lhr⁻¹

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on-line emitters under paired-row planting), T_5 - (6 hr^{-1} micro-tube under conventional planting) and T_6 - (6 hr^{-1} micro-tube under paired-row planting). Each emitter in the conventional planting served one plant and was placed beside the plant, whereas, in the paired-row planting pattern each emitter served two plants and was placed in the middle of the two rows.

Experiment II. To study the effect of micro irrigation supplies and planting pattern on soil moisture distribution and tomato yield in heavy soils. The experiment was carried out during period of January to April 2000.

In the Experiment I, irrigation supply through 6 hr^{-1} micro-tubes under paired-row planting gave the best results for tomato crop production. Thus micro-tubes of rated discharge 6 hr^{-1} were used in Experiment II. Four levels of irrigation [viz. irrigation at 0.6, 0.8, 1.0, and 1.2 times crop evapo-transpiration (ET_c) designated as I_1 , I_2 , I_3 and I_4 respectively] as main treatment, and two planting patterns [viz. Paired-row (P_1) and Four-row (P_2)] as sub-treatment were selected for the study. Thus, in all, there were eight combinations of irrigation level and planting pattern. Micro-tubes (\varnothing 1.2mm) of rated discharge 6 hr^{-1} (at operating pressure of 1.0 kg cm^{-2}) were punched and coiled around the laterals at 45cm regular spacing matching plant-to-plant spacing within the rows of tomato. Row-to-row distance was fixed as 40 cm in both the P_1 and P_2 . In the P_1 , one lateral served two rows of the plants and was placed in the middle of the two rows, whereas in the P_2 , one lateral served four rows of plants and was placed in the middle of the two inner rows. Eventually, each micro-tube in the paired-row planting pattern served two plants and

each micro-tube in the four-row planting pattern served four plants.

In both the experiments, irrigation was scheduled on alternate days using daily crop coefficient values for tomato determined by the method suggested by Doorenboss and Pruitt (1977), and pan-evaporation values of two days prior to the day of irrigation. The treatments were laid with 30 m long laterals (Low Density Poly Ethene pipe \varnothing 16mm). Emitters/micro-tubes were inserted into the laterals at 45 cm regular spacing matching plant-to-plant spacing within the rows of tomato. 'ACC-99' and 'Pusa Ruby' varieties of tomato (*Lycopersicon esculentum*) were used in Experiment I and II respectively, and recommended practices for cultivation of tomato were adopted.

To study the behaviour of soil moisture distribution pattern of emitters/microtubes under different discharge rates and planting patterns, soil samples were collected 24 hours after irrigation at three selected stages namely initial, crop-development and mid-season stage of tomato crop in a grid pattern, and moisture content of the samples was determined on dry weight basis using gravimetric method. In Experiment I in conventional planting, the soil samples were taken at 0, 10, 20, 30, 40 cm across the laterals and vertically from the position of the emitter, whereas, in paired-row planting the soil samples were collected at 0,10,20 and 60 cm across the laterals and at 0, 10, 20, 30, 40 cm vertically from the position of the emitter. In Experiment II, soil samples were collected at different distances from the micro-tube [(0, 20, 40, 60 cm for P_1), (0, 20, 40, 60, 80, 100, 120 cm for P_2)] across the laterals and at different depths (0, 10, 20, 30, 40, 50, 60 cm for both P_1 and P_2).

Picking of tomato commenced when the colour of the fruits changed from green to yellow/red. Tomato yield per hectare under different treatments was determined and significance of the treatments was tested. Analysis of variance was carried out for the yield data. Initial cost comparison of the paired row and four row planting patterns for a one hectare field under Experiment II was done.

RESULTS AND DISCUSSION

Experiment I. Vertical and lateral moisture distribution patterns in the soil profile around the emitters 24 hours after irrigation was found to be different under different treatments. This may be attributed to change in position of source and sink, and change in evaporative demand with stage of crop growth. Treatments T₁, T₃ and T₅ were under the conventional planting in which the source and sink were at the same position. In the treatment T₁, the moisture content in the vertical plane

underneath the emitters ranged between 39-27, 40-25, and 40-25 per cent for initial, crop development and mid season stages of crop growth (Table 1). Moisture content was found to be higher in the top layers and gradually decreased in downward direction. In the treatment T₃, soil moisture content vertically below the emitters varied between 42-24, 39-20, and 42-24 per cent for the three respective stages. On comparing the soil moisture distribution in T₁ and T₃, relatively higher moisture content was observed in the upper layers in T₃. Lateral distribution of water was also more in the case of T₃. In treatment T₅, relatively high moisture content (than that under T₁ and T₃) varying between 44-20, 44-20, and 41-23 per cent was observed during the initial, crop development and mid season stages of crop growth. Difference in emitter discharge rates might be the cause of the difference in the distribution of irrigation water in the soil profile.

Table 1 - Soil moisture (%) distribution in various treatments at selected crop stages in Experiment I

INITIAL STAGE	Conventional planting				Paired row planting			
	2 lhr ⁻¹ emitter							
Distance (cm)	0	10	20	30	0	10	20	60
10	39	35	33	28	43	40	38	32
20	35	31	27	26	41	35	33	29
30	33	28	25	24	33	30	28	28
40	27	25	23	24	28	25	24	27
4 lhr ⁻¹ emitter								
Distance (cm)	0	10	20	30	0	10	20	60
10	42	43	43	32	41	42	38	35
20	35	32	25	25	41	40	35	30
30	28	24	24	20	30	33	26	26
40	24	23	21	20	25	24	20	26

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INITIAL STAGE	Conventional planting				Paired row planting			
	6 hr⁻¹ micro tube							
Distance (cm)	0	10	20	30	0	10	20	60
10	44	40	38	39	42	40	39	37
20	40	35	33	31	40	36	34	32
30	30	26	30	30	28	24	25	27
40	20	19	19	25	24	23	22	24
	CROP DEVELOPMENT STAGE							
	2 hr⁻¹ emitter							
Distance (cm)	0	10	20	30	0	10	20	60
10	40	38	29	26	41	40	36	28
20	31	28	21	20	38	35	28	26
30	29	22	19	18	34	27	25	23
40	25	20	18	16	30	26	20	20
	4 hr⁻¹ emitter							
Distance (cm)	0	10	20	30	0	10	20	60
10	39	38	37	37	43	36	35	33
20	30	24	23	22	36	34	29	28
30	22	20	19	18	30	25	26	24
40	20	18	18	17	25	20	19	20
	6 hr⁻¹ micro-tube							
Distance (cm)	0	10	20	30	0	10	20	60
10	40	38	36	38	38	34	35	38
20	35	34	31	32	35	30	29	35
30	28	21	20	28	28	24	28	28
40	20	19	18	23	20	19	24	20
	MID SEASON STAGE							
	2 hr⁻¹ emitter							
Distance (cm)	0	10	20	30	0	10	20	60
10	40	34	30	29	42	36	34	31
20	36	28	29	25	37	33	30	29
30	31	30	23	21	34	30	27	28
40	25	23	20	19	30	29	25	24
	4 hr⁻¹ emitter							
Distance (cm)	0	10	20	30	0	10	20	60
10	42	37	33	28	41	38	32	30
20	37	32	29	27	35	31	30	28
30	27	26	24	23	33	37	29	26
40	24	22	20	19	41	38	32	30
	6 hr⁻¹ micro-tube							
Distance (cm)	0	10	20	30	0	10	20	60
10	41	40	35	34	42	38	35	33
20	38	39	30	29	36	36	34	32
30	26	32	24	27	36	30	24	29
40	23	22	21	25	23	20	20	22

In the paired row planting, unlike the conventional planting, the source and the sink were not at the same position. Irrigation was applied simultaneously to two plants through a single emitter/ micro-tube. Thus the operating time under paired row planting was more than that under conventional planting. The moisture distribution pattern under paired-row planting was observed to be different as compared to conventional planting pattern even for the same emitter (*Table 2*). In treatment T₂, moisture content in the soil profile beneath the emitters was higher in the upper layers and varied between 43-28, 41-30 and 42-30 per cent for initial, crop development and mid season stages of

crop respectively. Laterally also the moisture content was recorded to be higher at top layers which decreased gradually in the downward direction. In the treatment T₄ the moisture content varied between 41-25, 43-25 and 41-41 per cent for initial, crop development and mid season stages of tomato crop. Lateral moisture distribution was more in treatment T₄ as compared to treatment T₂. In treatment T₆, the moisture content, 24 hours after irrigation, varied between 42-24, 43-24, and 42-23 per cent for initial, crop development and mid season stage of tomato respectively. Lateral movement of water was observed to be more in T₆ as compared to T₄ and T₂.

Table 2 – Tomato (ACC 99 variety) yield (q/ha) under different treatments in Experiment I

Treatment	Conventional planting	Paired row planting	Average
2 lhr ⁻¹ emitter	150.12	159.71	154.91
4 lhr ⁻¹ emitter	159.72	186.32	173.02
6 lhr ⁻¹ micro tube	173.58	216.67	195.12
Average	161.44	187.56	

Observations on soil moisture distribution under both planting patterns revealed that the moisture content in the soil profile decreased gradually with increase in depth and radial distance with respect to the emitter. In 2 lhr⁻¹ emitters (treatments T₁ and T₂) the rate of vertical water movement below the emitters was higher than the rate of lateral movement, which was due to emitter's relatively slower rate of discharge than the intake rate of the soil. As the emitter discharge

increased from 2 lhr⁻¹ to 4 and 6 lhr⁻¹, the lateral spread of water was dominant over the vertical spread. Similar results have been reported by Yoset *et al.* (1976), Hacham *et al.* (1976), Goldberg *et al.* (1971), Brestler *et al.* (1971), Goel *et al.* (1993).

Observations on yield revealed that the paired-row planting gave relatively higher yields than the conventional planting (*Table 2*). Each treatment under paired-row planting (*viz.* T₂, T₄ and T₆) recorded higher

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yield as compared to conventional planting treatments viz. T₁, T₃ and T₅ respectively. Among the emitters, highest yields were observed in 6 lhr⁻¹ micro-tubes followed by 4, 2 lhr⁻¹ emitters. Among all the treatments, highest yield was recorded in the treatment T₆ (216.67 q /ha), which was significantly superior to those recorded under other treatments.

Experiment II. Vertical and lateral moisture distribution patterns were found to be different under different treatments and stages of crop growth (*Table 3*). Under the paired-row planting, the micro-tube served two plants. In the treatment I₁P₁ the moisture content in the soil profile (0-60 cm) beneath the source ranged between 40-19, 40-20 and 40-18 per cent during initial, crop-development and mid-season stages respectively. Lateral spread of water was found to

be more than the vertical spread. In the treatment I₂P₁ moisture content vertically below the source varied between 43-19, 41-22 and 40-20 per cent during the three stages respectively. On comparing the water spreads in I₁P₁ and I₂P₁, it was noted that the magnitude of spread was more in the case of I₂P₁. Similarly, the soil moisture in I₃P₁ and I₄P₁ ranged between 43-23, 41-23, 40-21 per cent and 43-20, 41-24, 42-27 per cent respectively, during the three successive stages of crop growth. On observing both vertical as well as lateral spread of water in the soil profile, it was noted that in all the irrigation levels the lateral movement was more than the vertical movement, with the magnitude of lateral spread increasing with increase in irrigation level.

Table 3 - Soil moisture (%) distribution (under 6 lhr⁻¹ micro-tube) in various treatments at selected crop stages in Experiment II

INITIAL STAGE	Paired row planting				Four row planting						
	Irrigation at 0.6 times ET _c										
Distance, cm	0	20	40	60	0	20	40	60	80	100	120
10	40	31	26	18	41	35	36	30	24	23	19
20	30	28	23	16	33	37	27	28	22	20	17
30	26	25	22	14	27	36	25	25	16	15	15
40	24	21	20	14	25	24	23	23	16	13	12
50	20	19	17	12	24	22	20	19	14	14	11
60	19	18	15	12	20	19	17	16	13	12	8
Irrigation at 0.8 times ET _c											
Distance, cm	0	20	40	60	0	20	40	60	80	100	120
10	43	36	34	27	43	38	34	31	26	24	24
20	32	31	29	23	35	33	30	28	25	21	21
30	28	27	25	20	28	30	27	26	25	20	18
40	24	24	24	17	26	26	24	24	22	18	17
50	21	20	20	16	23	22	23	21	19	17	14
60	19	18	17	14	22	24	22	20	17	15	11

INITIAL STAGE	Paired row planting				Four row planting						
	Irrigation at 1.0 times ET _c										
Distance, cm	0	20	40	60	0	20	40	60	80	100	120
10	43	36	35	30	44	36	35	35	31	26	25
20	35	31	30	29	38	33	32	31	30	25	24
30	29	29	25	23	32	31	29	28	27	25	23
40	27	25	23	16	30	28	27	27	25	23	21
50	23	23	22	14	26	25	24	23	23	21	17
60	23	19	17	14	22	22	22	21	19	18	16
Irrigation at 1.2 times ET _c											
Distance, cm	0	20	40	60	0	20	40	60	80	100	120
10	43	38	38	30	42	37	34	36	32	27	26
20	36	33	31	30	38	35	32	32	31	27	25
30	33	29	27	28	32	32	31	30	29	25	24
40	28	28	25	21	30	30	28	27	27	24	22
50	25	24	24	18	29	28	26	25	25	21	20
60	21	23	22	16	28	24	23	20	20	20	18
CROP DEVELOPMENT STAGE											
Irrigation at 0.6 times ET _c											
Distance, cm	0	20	40	60	0	20	40	60	80	100	120
10	40	31	34	24	43	35	33	31	33	26	18
20	33	29	28	24	35	32	30	29	29	25	17
30	28	25	18	22	32	29	27	26	25	25	14
40	25	23	17	20	29	27	25	24	22	22	13
50	24	21	17	17	25	25	23	21	20	18	11
60	20	19	15	15	22	22	22	19	18	15	11
Irrigation at 0.8 times ET _c											
Distance, cm	0	20	40	60	0	20	40	60	80	100	120
10	41	32	32	26	41	36	34	33	34	33	27
20	36	29	29	24	38	33	32	30	30	29	25
30	32	27	25	22	35	30	30	28	28	25	25
40	27	25	25	21	30	28	26	25	24	22	20
50	23	25	23	18	26	26	24	23	21	19	17
60	22	21	19	17	25	24	23	20	19	17	14
Irrigation at 1.0 times ET _c											
Distance, cm	0	20	40	60	0	20	40	60	80	100	120
10	41	34	35	29	42	38	35	33	35	33	27
20	36	32	31	28	40	34	32	32	34	32	28
30	33	30	26	26	36	31	30	30	31	27	24
40	27	28	22	24	33	28	28	29	26	23	22
50	25	25	20	19	27	27	26	25	23	21	19
60	23	22	20	18	26	25	23	24	22	19	15
Irrigation at 1.2 times ET _c											
Distance, cm	0	20	40	60	0	20	40	60	80	100	120
10	41	38	36	31	43	37	35	36	34	35	29
20	38	35	31	29	41	36	34	33	34	33	25
30	34	32	28	27	37	34	32	32	32	30	24
40	28	28	24	25	34	33	31	30	29	25	23

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INITIAL STAGE		Paired row planting				Four row planting					
50	26	25	22	24	30	30	29	27	25	23	21
60	24	24	20	22	28	27	25	24	22	20	18
MID SEASON STAGE											
Irrigation at 0.6 times ET_c											
Distance, cm	0	20	40	60	0	20	40	60	80	100	120
10	40	34	34	27	44	34	37	33	35	30	25
20	33	25	30	24	34	31	31	30	31	30	22
30	28	27	25	23	32	29	26	28	28	27	19
40	24	23	22	20	29	27	24	26	25	24	17
50	22	22	18	17	26	25	25	24	23	20	14
60	18	20	17	16	23	32	22	21	18	16	10
Irrigation at 0.8 times ET_c											
Distance, cm	0	20	40	60	0	20	40	60	80	100	120
10	40	31	38	30	45	37	36	31	36	37	22
20	33	31	32	30	36	35	32	31	33	33	25
30	29	28	27	26	33	32	29	28	30	29	24
40	27	25	24	23	30	27	27	25	26	25	21
50	22	23	19	18	28	25	25	24	22	22	18
60	20	21	19	16	27	24	24	23	18	19	16
Irrigation at 1.0 times ET_c											
Distance, cm	0	20	40	60	0	20	40	60	80	100	120
10	40	34	36	34	45	37	34	35	36	33	28
20	35	32	34	30	38	34	34	33	36	31	25
30	33	29	29	27	33	31	31	30	32	30	24
40	29	29	26	34	31	29	29	29	29	26	20
50	25	26	22	20	29	26	26	24	23	22	18
60	21	24	20	18	28	25	22	21	22	20	17
Irrigation at 1.2 times ET_c											
Distance, cm	0	20	40	60	0	20	40	60	80	100	120
10	42	34	37	38	43	38	36	36	36	35	31
20	38	33	36	34	40	37	34	34	36	34	29
30	33	30	31	32	38	35	32	32	34	34	27
40	30	28	27	29	34	33	31	30	32	30	25
50	28	27	24	23	32	31	29	28	28	24	24
60	27	25	21	20	30	29	28	25	23	18	19

In the four-row pattern of planting, each micro-tube served four plants. Thus the time of operation of laterals in four-row planting was more than that in paired-row planting. Soil moisture distribution pattern under the four-row planting was observed to be different than that obtained in the paired-row planting under the same irrigation level. In the treatment I₁P₂,

moisture content in the soil profile beneath the source ranged between 41-20, 43-22 and 44-23 per cent during initial, crop-development and mid season stages respectively. Here, the lateral spread of water was found to more than the vertical spread. In the treatments I₂P₂ and I₃P₂, the soil moisture ranged between 43-22, 41-25, 45-27 per cent and, 44-22, 42-26,

45-28 per cent respectively, during the three stages. As the level of irrigation increased from I_1 to I_3 , the soil moisture spread also increased with the lateral spread being more than the vertical spread. Similar trend was observed in the case of I_4P_2 where the soil moisture varied between 42-26, 43-28 and 43-30 per cent, during the three stages respectively. Thus, like the case with paired-row planting, with increase in irrigation level, lateral spread was found to be more than the vertical spread. It was also observed that the moisture spread both vertically and laterally was more in case of four-row planting than the paired-row planting pattern with the magnitude of lateral spread being more than the vertical spread.

On the whole, observations on soil moisture distribution revealed that magnitude of spread of water in the soil profile was more in lateral direction than the vertical direction. As the irrigation level increased the lateral spread was more pronounced than the vertical spread. Magnitude of the lateral spread was relatively more in case of four-row planting than the paired-row planting. The results are in close agreement with earlier studies by Goldberg and Shmueli (1970), Yoset *et al.* (1976).

Tomato yield observations with regard to irrigation levels revealed that highest average yield was recorded in I_3 level followed I_4 , I_2 , and minimum in case of I_1 level (*Table 4*). Between planting patterns, P_1 gave higher average yield than P_2 . Observations revealed that at lower levels of irrigation (*viz.* irrigation at 0.6 times ET_c and 0.8 times ET_c), P_1 gave higher yields than P_2 , whereas at higher levels of irrigation (irrigation at 1.0 times ET_c and 1.2 times ET_c), P_2 performed better. Yield reduction under P_2 as compared to P_1 in deficit irrigations was more pronounced than the yield increase under irrigation at 1.0 and 1.2 times ET_c ; thus the overall effect was that the paired row planting gave higher average yield than four row planting. Among the various treatments, highest yield (324.19 q ha^{-1}) was obtained in I_3P_2 that was significantly superior to other treatments. Least effective treatment was I_1P_2 that gave a yield of 149.99 qha^{-1} , which was significantly inferior to yields under other treatments. On determining the initial investment on drip system layout it was found that under four-row planting, a cost saving on initial investment to the tune of 35.21 per cent over paired-row planting can be achieved (*Table 5*).

Table 4 - Tomato (Pusa ruby variety) yield (q/ha) under different treatment treatments in Experiment II

Treatment	Paired-row planting	Four row planting	Average
Irrigation at 0.6 times ET_c	167.71	149.99	158.85
Irrigation at 0.8 times ET_c	294.58	253.16	273.87
Irrigation at 1.0 times ET_c	312.66	324.19	318.43
Irrigation at 1.2 times ET_c	276.00	309.99	293.00
Average	262.74	259.33	

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Table 5 - Initial cost comparison of the paired row and four row planting patterns for a one hectare field in Experiment II

S. No.	Description	Unit price* Rs.	Paired-row planting		Four-row planting	
			Quantity	Amount Rs.	Quantity	Amount Rs.
1.	Length of Lateral	6.00 /m	8334	50004.00	4167	25002.00
2.	Microtube	1.50 /m	9260	13890.00	4630	6945.00
3.	Screen Filter	5600.00	1	5600.00	1	5600.00
4.	Chemigation Unit	5000.00	1	5000.00	1	5000.00
5.	Pressure Gauge	200.00	1	200.00	1	200.00
6.	Gate Valve	400.00	2	800.00	2	800.00
7.	Lateral Adopter	10.00	278	2780.00	139	1390.00
8.	End Plug	2.00	278	556.00	139	278.00
9.	Main Line PVC (\varnothing 50mm)	50.00/m	333	16650.00	330	16650.00
10.	Punch	70.00	1	70.00	1	70.00
Total (Rs.)				95480.00		61865.00

* Rates prevailing during April 2000

Adding installation per ha. Cost 2 per cent of total cost, then

i) Total Cost per ha; for Paired-row planting – Rs. 97389.60

ii) Total Cost per ha; for Four-row planting – Rs. 63102.30

Cost saving by using Four-row planting pattern over Paired-row planting pattern = Rs. 34287.30 per ha (i.e. 35.21 per cent).

CONCLUSIONS

In the Experiment I, moisture distribution in the soil profile under emitters with discharge rates 2,4,6 lhr⁻¹ in combination with conventional, paired-row planting was determined. Observations revealed that under 2 lhr⁻¹ emitters, the vertical movement of irrigation water was higher than that observed under 4 and 6 lhr⁻¹ emitters. Under the 6 lhr⁻¹ micro-tube, lateral water spread was more as compared to that under 4 and 2 lhr⁻¹ emitters. Relative spread of irrigation water in the paired- row planting was more than in the conventional planting.

In the Experiment II, moisture distribution pattern in the soil profile under micro-tubes (6 lhr⁻¹) as

influenced by different irrigation supplies in combination with paired-row, four-row planting was observed. Here, it was noted that the lateral and vertical spread of water in the soil increased with the amount of irrigation. In all the treatments, the lateral spread of irrigation water was more than the vertical spread, with the magnitude of spread being more under four-row planting than that under paired-row planting.

Observations on yields during the Experiment I revealed that paired-row plantings of tomato (var. ACC - 99) gave yields higher than the conventional planting under each of the three emitters used. Among the emitters highest yield was obtained with 6 lhr⁻¹ drippers under paired-row planting.

In the Experiment II, the amount of irrigation was varied under paired-row, four-row plantings of tomato (var. Pusa Ruby). Treatments with deficit irrigation gave lower yields. The reduced amount of irrigation water application was insufficient to cover all evaporative demands of crop and caused a stress condition that adversely affected tomato yield. Highest yield was obtained in the treatment combination of four-row planting coupled with irrigation at 1.0 times crop evapo-transpiration through 6 lhr⁻¹ micro-tubes.

In the final analysis, fulfillment of 100 per cent of tomato crop evapo-transpiration need utilizing micro-irrigation (rated discharge- 6 lhr⁻¹) combined with four-row planting achieved a cost saving of 35.21 per cent on initial investment with significant gain in yield over paired-row planting in the heavy soils of central India.

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