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Impact of micro-irrigation and mulching techniques on yield, water use efficiency, water productivity, and economic viability of tomato under rain shelter

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Abstract
In agriculture, the adoption of micro-irrigation and mulching techniques stands out as effective water Management strategies, aimed at conserving water and enhancing water use efficiency. Hence, this study investigated how these practices impact the yield, water use efficiency, water productivity, and economics of tomato cultivation. The study encompasses five micro irrigation techniques, namely rain hose, surface drip, and subsurface drip at 10, 15 and 20 cm depths, coupled with two mulching treatments (no mulch and organic mulch using dry banana leaves @ 10 t ha^{-1}). Results indicate that number of fruits $plant^{-1}$ (35.69) and fruit weight (43.60 g) were highest in subsurface drip at 10 cm depth. Organic mulch recorded the highest number of fruits $plant^{-1}$ (31.37) and fruit weight (39.69 g) compared to no mulch. The combination of subsurface drip irrigation at 10 cm depth with organic mulch recorded the highest fruit yield $plant^{-1}$ (1.44 kg), water use efficiency (7.67 kg m^{-3}), net returns (₹ 5.43 lakhs ha^{-1}) and B:C ratio (2.04). Thus, adopting subsurface drip irrigation at 10 cm depth with organic mulch (dry banana leaves) at 10 t ha^{-1} could be a viable option for achieving higher yields, water use efficiency, and net returns in tomato.

Keywords: Tomato, surface drip, subsurface drip, organic mulch, rain hose

Introduction
The impact of climate change on water resources is undeniable and agriculture being a water-intensive sector with a withdrawal volume of 70% is more vulnerable to these changes (Ingrao *et al.*, 2023) [3]. In the current situation, maximizing the use of irrigation water is crucial to raise agricultural output and ensuring the food security of the world's growing population. In India, the annual per capita accessible and utilizable water resources are 2384 and 1086 m^3, respectively. By 2050, the availability is predicted to further decline to 760 m^3 (Kapoor *et al.*, 2021) [4]. Under-irrigation leads to stunted growth, poor yields and diminished quality whereas over-irrigation results in water wastage and surface and groundwater pollution due to nutrient leaching. As a result, water resources should be utilized more efficiently and productively. This could be accomplished by implementing improved irrigation techniques and better water management strategies.

Micro-irrigation technique guarantees 30 to 70% water savings than conventional irrigation methods for vegetables (Zaman *et al.*, 2001) [8]. Drip irrigation technique releases a small quantity of water into the soil surface or plant root zone through emitters (Kumari and Kaushal, 2014) [6], whereas in subsurface method, water is applied *via* drippers installed below the soil surface, with the same discharge rates as surface drip. Rain hose irrigation is a low-cost spray technology with flexible pipes having nano-punched drip hole patterns. It ensures precise water delivery, reduces leaching losses, enhances water use efficiency and portability (Ayyadurai *et al.*, 2020) [1]. Mulching is commercially implemented in most vegetables grown in Kerala, is one such water management strategy that reduces rainwater runoff by retaining it at the soil surface, giving it more time to seep into the soil and thus increasing water use efficiency (WUE) (Ranjan *et al.*, 2017) [7]. Hence, there is considerable scope for the practice and application of mulching in crop production for soil and water conservation.

One significant impediment that significantly affects tomato yield and quality is water. Being a tropical plant, it requires a constant supply of water, and hence scarcity of water can adversely affect crop growth and yield (Kumar and Khanna, 2019) [5]. Therefore, the purpose of this study is to investigate how mulching and micro irrigation interact to affect tomato production, water productivity, WUE, and economics under rain shelter.

Materials and Methods

The experimental site was located in Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala and study period was from February to May, 2021.The farm is situated at 8.5º North latitude and 76.9º East longitude at an altitude of 29 m above mean sea level. The experimental site's soil was identified as sandy clay loam, characterized by high organic carbon (1.21%), medium available nitrogen (252 kg ha^{-1}), potassium (242 kg ha^{-1}) and high available phosphorus (68.2 kg ha^{-1}). The soil demonstrated a slightly acidic pH (6.1), with a field capacity (19.25%) and permanent wilting point (7.63%). The tomato variety Vellayani Vijai released from the COA, Vellayani was used as test crop for the study.

The experimental design was split plot with five types of micro irrigation, i_1 (surface drip), i_2 (rain hose), i_3 (subsurface drip at 10 cm), i_4 (subsurface drip at 15 cm) and i_5 (subsurface drip at 20 cm) and two mulching materials m_1 (no mulch) and m_2 (organic mulch) as main and sub plot treatments respectively, replicated four times. Dry banana leaves @ 10 t ha^{-1} were used as organic mulch.

Pressure compensating drippers, each with a discharge rate of 2 L h^{-1} at 60 cm spacing were connected to the laterals to deliver water to individual plants. The duration of the delivery of water to each treatment was controlled with the help of gate valves provided at the inlet of each lateral. Irrigation was scheduled on a daily basis based on the crop's water requirement, which was calculated using the following relationship,

$$V = E_p \times K_c \times K_p \times W_p \times S_p$$

Where

V- Water requirement (litre day^{-1} $plant^{-1}$)

E_p - Maximum pan evaporation (8mm day^{-1});

K_c – Crop coefficient (Initial stage-0.40; Development stage-0.70; Maturity stage-0.90; End stage-0.85)

K_p - Pan coefficient (0.7)

W_p - Wetted area (0.9 m^2

S_p - Spacing (0.6m x 0.6m)

Healthy one month old ‘Vellayani Vijai’ seedlings were transplanted at 60 x 60 cm spacing. Water soluble fertilizers, *viz.*, urea @ 327 kg ha^{-1}, polyfeed (19:19:19) @ 198 kg ha^{-1}, mono ammonium phosphate (12:61:0) @ 44 kg ha^{-1} and potassium nitrate (13:0:45) @ 540 kg ha^{-1} were given as fertigation at 3 days interval using a venturi system. For mulching, dried banana leaves @ 10t ha^{-1} were spread over the prepared beds soon after transplanting.

The yield attributes of tomato *viz.*, number of fruits $plant^{-1}$, fruit weight, fruit yield $plant^{-1}$ and fruit yield m^{-2} were taken at each harvest and the mean was calculated. WUE and water productivity was calculated using the following formula and expressed in kg m^{-3}

$$\text{WUE} = \frac{\text{Fruit yield (kg)}}{\text{Total water utilized } (\text{m}^3)}$$

$$\text{Water productivity} = \frac{\text{Total biomass produced (kg)}}{\text{Total water utilized } (\text{m}^3)}$$

The net returns and B:C ratio was calculated as follows:

Net returns (₹ ha^{-1}) = Gross returns – Cost of cultivation

$$\text{B: C ratio} = \frac{\text{Gross returns ha}^{-1} (₹)}{\text{Cost of cultivation ha}^{-1} (₹)}$$

Data generated were subjected to statistical analysis by applying ANOVA for split plot design and significance was tested (Gopinath *et al.*, 2020) [2].

Results and Discussion

Yield attributes

Data pertaining to yield attributes of tomato influenced by types of micro irrigation and mulching are shown in Table 1. Number of fruits $plant^{-1}$ and fruit weight were higher in (I_3) subsurface drip irrigation at 10 cm (35.69, 43.60 g) respectively, while (I_2) rain hose irrigation yielded the lowest number of fruits (25.77) and fruit weight (33.72g) and was on par with surface drip irrigation (I_1). The availability of optimum soil moisture and nutrients in the root zone resulted in increased flowering, flower retention, and translocation of photosynthates, hence the higher fruit number and fruit weight in the subsurface drip method. Fruit yield $plant^{-1}$ and fruit yield m^{-2} were significantly higher in (I_3) subsurface drip irrigation at a depth of 10 cm (1.41 kg, 3.44 kg) respectively. The deeper placement of laterals at 10, 15 and 20 cm depths increased the fruit yield by 43.87%, 32.65% and 22.44 over rain hose irrigation.

Yield varied with placement of laterals and was 8.46% and 17.5% higher in subsurface drip irrigation at 10 cm depth compared to subsurface drip at 15 and 20 cm depth respectively. Hence higher yield could be obtained by maintaining optimum soil moisture conductive to plant growth, which is feasible under shallow drip tape installation. Higher the water content of soil around the emitters, better the water transmission to the surrounding soil. As a result, maintaining the drip tube within the root zone suitably below the soil surface effectively replenishes the root zone, reducing evaporation losses due to restricted upward capillary flow.

Mulching also had a significant influence on the yield attributes of tomato. Use of organic mulch increased the average number of fruits, fruit weight, fruit yield $plant^{-1}$ and fruit yield m^{-2} by 9.26%, 10.61%, 9.73% than no mulch. This is due to the conservation of moisture, improved microclimate, addition of organic matter which improved soil physical conditions and fertility, enhancing plant growth and yield. Significantly highest fruit yield plant-1 and fruit yield m^{-2} were recorded for the combination (I_3M_2) subsurface drip irrigation at 10 cm depth with organic mulch (1.44kg, 3.54kg) respectively. This is because of improved growth and yield attributes resulting from the better metabolic activity of the plant probably due to the consistent supply of soil moisture and nutrients in the root zone. The lowest fruit yield $plant^{-1}$ and fruit yield m^{-2} was recorded in (I_2M_1) rain hose irrigation without mulch (0.91kg, 2.05kg) respectively.

Table 1: Effect of micro irrigation and mulching on yield attributes and economics of tomato

Treatments	Number of fruits	Fruit weight (kg)	Fruit yield plant^{-1} (kg)	Fruit yield m^{-2} (kg)
Types of micro irrigation				
I_1 Surface drip	27.08	34.17	1.03	2.40
I_2 Rain hose	25.77	33.72	0.98	2.25
I_3 Subsurface drip at 10 cm	35.69	43.60	1.41	3.44
I_4 Subsurface drip at 15 cm	31.95	40.24	1.30	3.15
I_5 Subsurface drip at 20 cm	29.72	37.19	1.20	2.86
S.Em (±)	0.55	0.70	0.03	0.08
CD (0.05)	1.784	2.298	0.088	0.246
Mulching				
M_1 No mulch	28.71	35.88	1.13	2.68
M_2 Organic mulch	31.37	39.69	1.24	2.96
S.Em(±)	0.29	0.34	0.01	0.02
CD (0.05)	0.928	1.064	0.019	0.055
Interaction				
I_1M_1	25.64	32.67	1.01	2.33
I_1M_2	28.53	35.67	1.06	2.47
I_2M_1	24.25	32.21	0.91	2.05
I_2M_2	27.29	35.24	1.05	2.46
I_3M_1	34.89	40.57	1.37	3.35
I_3M_2	36.49	46.64	1.44	3.54
I_4M_1	29.67	38.79	1.24	2.98
I_4M_2	34.23	41.69	1.37	3.33
I_5M_1	29.11	35.17	1.14	2.70
I_5M_2	30.33	39.22	1.26	3.03
S.Em(±)	0.66	0.75	0.01	0.04
CD (0.05)	NS	NS	0.043	0.123

Water use efficiency

Data regarding the effect of types of micro irrigation and mulching on WUE has been furnished in the Fig. 1 & 2. Subsurface drip irrigation at 10cm depth (I_3) obtained significantly higher WUE (7.47 kg m^{-3}). This is due to improved crop performance and greater yield from the efficient use of available water and nutrients provided at frequent intervals throughout the crop period to fulfill crop demand. The evaporation loss from subsurface placement of drip lines is very low because of limited water availability on the soil surface and the low upward movement of water retaining sufficient moisture beneath the soil surface for root uptake. The lowest WUE was noticed in rain hose irrigation (I_2) (4.89 kg m^{-3}) and was on par with surface drip irrigation (I_1).

Between the mulches, WUE was higher in (M_2) organic mulch (6.42 kg m^{-3}) than no mulch (M_1). Subsurface drip irrigation with organic mulch (I_3M_2) recorded the highest WUE (7.67 kg m^{-3}) and the lowest was in rain hose irrigation without mulch (I_2M_1) (4.44 kg m^{-3}). This could be attributed to the efficiency of organic mulch in moisture conservation by reducing evaporation, as well as the effectiveness of subsurface drip irrigation in maintaining optimum soil moisture throughout crop growth which resulted in a higher yield and subsequently a high WUE.

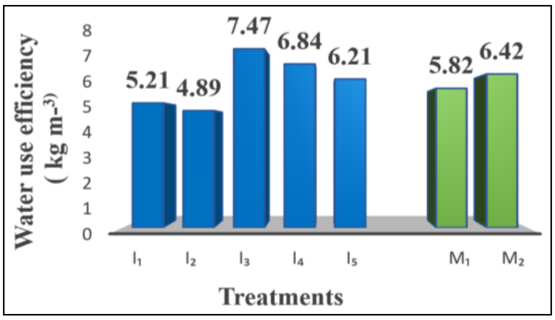

Fig 1: Effect of micro irrigation and mulching on WUE

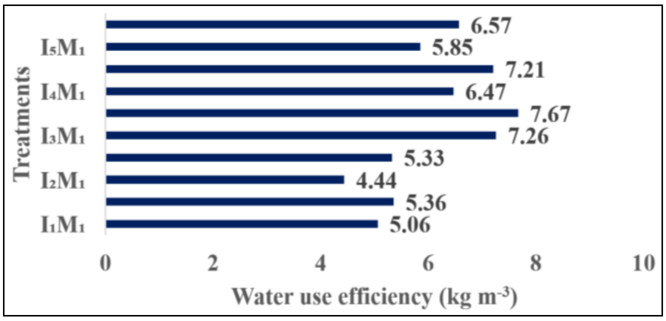

Fig 2: Interaction effect of micro irrigation and mulching on WUE

Water productivity

The influence of types of micro irrigation and mulching on water productivity is shown in Fig. 3. Water productivity was 55.10% and 46.15% higher in subsurface drip irrigation at 10 cm depth (I_3) compared to rain hose irrigation (I_1) and surface drip irrigation (I_2). Placement of drip laterals also has a significant influence on water productivity with an increase of 7.95% and 21.40% in subsurface drip at 10 cm depth (I_3) when compared to subsurface drip at 15 cm depth (I_4) and 20 cm depth (I_5). Organic mulch enhanced the water productivity by 2.94% over no mulch.

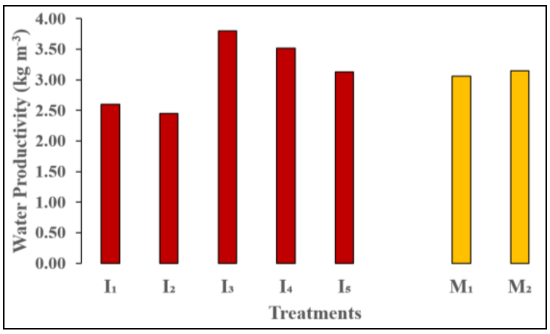

Fig 3: Effect of micro irrigation and mulching on water productivity

Net returns and B:C ratio

The economic analysis was worked out in terms of net returns and B:C ratio as shown in Table 2. The highest net returns and B:C ratio was observed in (I_3) subsurface drip irrigation at 10 cm depth (5.14 lakhs ha^{-1}, 1.99) and the lowest was in (I_1) rain hose irrigation (1.90 lakhs ha^{-1}, 1.39). Organic mulch (M_2) recorded highest net returns (3.77 lakhs ha^{-1}) and B:C ratio (1.73) than no mulch (M_2). The highest net returns and B:C ratio were recorded in (I_3M_2) sub surface drip irrigation at 10 cm depth with organic mulch (5.43 lakhs ha^{-1}, 2.04) whereas the lowest was in (I_2M_1) rain hose irrigation without mulch (1.29 lakhs ha^{-1},1.26).

Table 2: Effect of micro irrigation and mulching on economics of tomato

Treatments	Net returns (₹ lakhs ha^{-1})	B:C ratio
Types of micro irrigation		
I_1 Surface drip	2.02	1.39
I_2 Rain hose	1.90	1.39
I_3 Subsurface drip at 10 cm	5.14	1.99
I_4 Subsurface drip at 15 cm	4.28	1.82
I_5 Subsurface drip at 20 cm	3.41	1.66
S.Em (±)	0.23	0.04
CD (0.05)	0.738	0.144
Mulching		
M_1 No mulch	2.92	1.57
M_2 Organic mulch	3.77	1.73
S.Em(±)	0.05	0.01
CD (0.05)	0.165	0.031
Interaction		
I_1M_1	1.81	1.35
I_1M_2	2.23	1.43
I_2M_1	1.29	1.26
I_2M_2	2.51	1.52
I_3M_1	4.85	1.93
I_3M_2	5.43	2.04
I_4M_1	3.76	1.72
I_4M_2	4.79	1.92
I_5M_1	2.91	1.56
I_5M_2	3.90	1.75
S.Em(±)	0.05	0.02
CD (0.05)	0.165	0.070

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Conclusion

The study revealed that both micro irrigation methods and mulching significantly influenced the yield attributes, water use efficiency (WUE), water productivity, as well as economic returns (net returns and B:C ratio) of tomato cultivation. Subsurface drip irrigation at 10 cm depth exhibited superior performance in terms of yield attributes, WUE, water productivity, and economic returns compared to rain hose irrigation and surface drip irrigation. Additionally, the combination of subsurface drip irrigation at 10 cm depth with organic mulch demonstrated the highest yield, WUE, water productivity, net returns, and B:C ratio. These findings underscore the importance of adopting efficient irrigation techniques and mulching practices for enhancing tomato production, conserving water resources, and improving economic profitability in agriculture.

References

1. Ayyadurai P, Shanmugam PS, Sangeetha, M. Rain hose irrigation technology in groundnut – A new innovation in irrigation system. Biotica Research Today. 2020;2(8):842-843.
2. Gopinath PP, Parsad R, Joseph B, Adarsh VS. GRAPES agri 21: Collection of shiny apps for data analysis in agriculture. Journal of Open Source Software. 2021;6(63):3437-3441.
3. Ingrao C, Strippoli R, Lagioia G, Huisingh D. Water scarcity in agriculture: An overview of causes, impacts and approaches for reducing the risks. Heliyon. 2023;9(8):1-16.
4. Kapoor R, Kumar A, Sandal SK, Sharma A, Raina R, Thakur KS. Water and nutrient economy in vegetable crops through drip fertigation and mulching techniques: A review. Journal of Plant Nutrition. 2022;45(15):2389-2403.
5. Kumar R, Khanna R. Comparative study of different irrigation methods on tomato crop in western Uttar Pradesh. International Journal of Chemical Studies. 2019;7(3):59-64.
6. Kumari R, Kaushal A. Drip fertigation in sweet pepper: A Review. International Journal of Engineering Research and Applications. 2014;4(8):144-149.
7. Ranjan P, Patte GT, Prem M, Solanke KR. Organic mulching–A water saving technique to increase the production of fruits and vegetable. Current Agriculture Research Journal. 2017;5(3):371-380.
8. Zaman WU, Arshad M, Salem K. Distribution of nitrate nitrogen in the soil profile under different irrigation methods. International Journal of Agriculture and Biology. 2001;2:208-209.