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Impact of fertigation levels on economics of hybrid tomato production

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Abstract

An experiment was carried out to study the effect of fertigation levels on economics of hybrid tomato production at Instructional Farm of Department of Irrigation and Drainage Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during the rabi season of 2023-24 and 2024-25. The experiment was laid out in Randomized Block Design (RBD) with five treatments which include four drip fertigation levels (120%, 100%, 80% and 60% of RDF) and control treatment of traditional fertilization at 100% RDF. These all treatments are replicated four times. Benefit-cost ratio was observed maximum for treatment T₁ (120% RDF).

Keywords: benefit-cost ratio, fertigation, drip, tomato, RDF, WUE

Introduction

Tomato (*Solanum lycopersicum*) is a prominent solanaceous vegetable crop extensively cultivated in India, holding a prime position among vegetables. It is a high valued crop consumed both fresh in salads and cooked in curries. Tomato has achieved significant worldwide importance and globally known as the 'love apple', 'golden apple' or 'poor man's apple'. It is a rich source of vitamins A and C, as well as potassium. The red colour is due to lycopene pigment, which acts as a potent antioxidant for reducing damage from free radicals (Ayyar, 2019) ^[1]. Major tomato-producing states in India include Andhra Pradesh, Madhya Pradesh, Karnataka, Gujarat, Maharashtra, Tamil Nadu, Odisha, and West Bengal.

In the year 2024–25, tomato cultivation in India covered an area of 853.27 thousand hectares, producing 25,959.43 thousand tonnes with a productivity of 27.7 tonnes per hectare, indicating improved yield levels despite a slight decline in cultivated area. During the same year in Maharashtra, tomato was grown over 56.47 thousand hectares, with a production of 1,512.37 thousand tonnes and a productivity of 26.2 tonnes per hectare, reflecting better performance in terms of output and efficiency compared to earlier years.

India ranks as the third largest producer and consumer of fertilizers globally. However, the nutrient consumption per hectare and fertilizer use efficiency remain notably low within the country. The primary reasons for this low efficiency include the types of fertilizers used and the application methods typically adopted by Indian farmers. Consequently, there is a clear necessity to develop an appropriate fertilizer application method that can enhance both the quantity and quality of crop yields. Fertigation is the technique of applying water-soluble solid fertilizers or liquid fertilizers directly through a drip irrigation system. In fertigation, nutrients are delivered directly into the wetted soil volume beneath the emitter, where root activity is most concentrated (Ayyar, 2019) ^[1].

Drip fertigation combined with mulching stands as one of the most effective management strategies, capable of significantly improving water management practices. The benefits of mulching in vegetable crop production are well-established. Mulch is essentially a protective layer of material spread over the soil surface. It enriches and safeguards the soil while creating a more favourable growing environment. Simultaneously, it acts as a barrier to moisture loss from the soil. Mulches can efficiently reduce water vapour loss, soil erosion, weed proliferation, and nutrient leaching. Mulching mitigates soil deterioration, curtails weed infestation, provides a beneficial microclimate for root development, and inhibits water evaporation. The plastic

materials commonly used for mulching are polyvinyl chloride or polyethylene films, with polyethylene being the preferred choice for crop production.

Materials and Methods

A study was conducted during rabi season of 2024-25 to examine the effects of different fertigation levels on hybrid tomato production at Instructional Farm of Department of Irrigation and Drainage Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

Climate at Experimental Site

Akola is geographically situated between North latitudes 20°16' and 21°17', and East longitudes 76°38' and 77°38'. Akola station receives an average annual rainfall 819 mm. The climate of Akola is subtropical semi-arid, featuring three distinct seasons: a hot and dry summer from March to May, a warm and rainy monsoon from June to October, and a mild, cold winter from November to February. The temperature at Akola varies between 12.6 °C to 42.4 °C.

Details of Experimentation

The experiment was laid out in Randomized Block Design (RBD) with five treatments which include four drip fertigation levels and control treatment of which details are as given in following Table 1.

Table 1: Treatment details

Treatments	Specification
T ₁	Drip fertigation with 120% of RDF
T ₂	Drip fertigation with 100% of RDF
T ₃	Drip fertigation with 80% of RDF
T ₄	Drip fertigation with 60% of RDF
T ₅	Conventional application of fertilizer with 100% RDF (Soil application of basal dose of 50% N + 100% P + 100% K through fertigation at the time of transplanting and remaining 50% N in twelve equal splits at an interval of ten days)- Control

Tomato seedlings (Syngenta Saaho) were transplanted in a double row with spacing of 90 cm x 60 cm on ridge.

Irrigation and Fertigation Management

Prior to transplanting, a common irrigation was provided across all plots to bring the soil to field capacity. Accounting for the use of polyethylene mulch, which conserves approximately 20% of irrigation water (Deshmukh, 2015) [3], the water requirement for the tomato crop under drip was estimated at 80% of crop evapotranspiration (ET_c). It was calculated using modified Penman- Monteith model, which is expressed as:

$$ET_o = \frac{0.408 \Delta (R_n - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34 u_2)}$$

where,

ET_o: Reference evapotranspiration, mm day⁻¹

R_n: Net radiation at the crop surface, MJ m⁻² day⁻¹

G: Soil heat flux density, MJ m⁻² day⁻¹

T: Air temperature at 2 m height, °C

U₂: Wind speed at 2 m height, m s⁻¹

E_s: Saturation vapour pressure, kPa

e_a: Actual vapour pressure, kPa

Δ: Slope vapour pressure curve, kPa °C⁻¹

γ: Psychrometric constant, kPa °C⁻¹

The values of crop coefficient used for different growth stages of tomato crop are referred from FAO 56. The crop evapotranspiration values for tomato crop is calculated by using following formula.

$$ET_c = K_c \times ET_o$$

where,

ET_c = crop evapotranspiration (mm d⁻¹)

K_c = crop coefficient (dimensionless)

ET_o = reference crop evapotranspiration (mm d⁻¹)

Irrigation and Fertigation scheduling

To achieve optimal and efficient production, irrigation for the tomato crop was scheduled every day. The recommended fertilizer dose of 300:150:150 N:P:K kg/ha was considered. In treatments T₁ to T₄, water soluble fertilizers (source – 19:19:19 WSF complex and urea) through drip fertigation was applied in 12 equal splits at an interval of 10 days. In control treatment T₅, basal dose of 50% N + 100% P + 100% K (sources – Urea and 19:19:19 WSF complex) were given as conventional fertilization through drip fertigation at the time of transplanting and remaining 50% of N (source-Urea) was given through drip fertigation.

Yield of tomato

The yield of tomato from a net plot in every treatment was observed in every picking. The total yield of the fruit harvested from the net plot was recorded by cumulating yield per picking and expressed in kg per plot and then it is converted into quintal per hectare.

Cost economics

To compare the net returns and benefit-cost ratio, the cost economics of all treatments was worked out. For this purpose, the life period of polyvinyl chloride items was considered as 10 years and for the rest of G.I. items, and motor pump set as 25 years. Standard market rates were considered for each item. Fixed cost, operating cost, net return, and benefit-cost ratio for each system were worked out as follows.

a) Fixed cost

Fixed cost comprised of interest on initial cost and depreciation on the system. The interest calculated on the capital was at the rate of 10 per cent per annum. The depreciation of the system was worked out by the straight-line method as follows.

$$D = \frac{(I - S)}{L}$$

where,

D= Depreciation per annum

I= Initial cost of system

S= Salvage value @ 10%

L= Expected life period of the system

Operating cost

Operating cost is the amount that is paid by the cultivator in cash throughout the cultivation period. Total operating cost comprised of operating cost of the system and interest on operating cost at the rate of twelve per cent per annum.

Total cost

Total cost comprised of fixed cost-plus operating cost. Total cost per ha was calculated for comparison on a per hectare basis.

Gross monetary return

This is worked out by considering the yield of produce and its selling price.

Benefit-cost ratio

The benefit-cost ratio was estimated by using the following formula.

$$\text{Benefit-cost ratio} = \frac{\text{Gross return per treatment}}{\text{Total cost per treatment}}$$

Results and Discussion**Water requirement of tomato**

Irrigation equal to 80% ETC was provided daily. The stage wise irrigation water applied is as given in Table 2.

Table 2: Water requirement of tomato

Stage	Particulars	Total water applied (0.8 ETC), mm	
		2023-24	2024-25
	Before transplanting	18.40	20.23
I	Initial	76.00	25.23
II	Development	133.44	94.68
III	Mid	136.24	143.95
IV	Late	96.80	32.33
	Total water applied, mm	460.88	316.42

It is cleared that maximum irrigation water was required during mid stage followed by development, late stage while minimum irrigation water was required during initial stage.

Yield of Tomato

Yield of tomato during each picking was cumulated to obtain total yield of tomato and presented in Table 3.

Table 3: Treatment wise hybrid tomato production

Sr. No.	Particulars	Year	T ₁	T ₂	T ₃	T ₄	T ₅
1	Total yield, q/ha	2023-24	329.91	305.01	274.16	251.60	202.35
		2024-25	838.67	781.34	722.53	656.31	747.74

Benefit Cost Ratio

Benefit cost ratio for hybrid tomato production was estimated considering market rate of tomato as Rs.1500/qtl and presented in Table 4 and Table 5.

Table 4: Cost economics of hybrid tomato production for 2023-24

Treatment	Yield of Tomato (q/ha)	Gross Return (Rs/ha)	Total Cost (Rs/ha)	Net Return (Rs/ha)	BC Ratio
T ₁	329.91	494865	157756	337109	3.14
T ₂	305.01	457515	147037	310478	3.11
T ₃	274.16	411240	136317	274923	3.02
T ₄	251.60	377400	130597	246803	2.89
T ₅	202.35	303525	120973	182552	2.51

Table 5: Cost economics of hybrid tomato production for 2024-25

Treatment	Yield of Tomato (q/ha)	Gross Return (Rs/ha)	Total Cost (Rs/ha)	Net Return (Rs/ha)	BC Ratio
T ₁	838.67	1258005	141033.88	1116971	8.92
T ₂	781.34	1172010	135516.36	1036494	8.65
T ₃	722.53	1083795	125998.84	957796	8.60
T ₄	656.31	984465	119481.32	864984	8.24
T ₅	747.74	1121610	135516.36	986094	8.28

The benefit cost ratio was observed highest for treatment T₁ followed by T₂, T₅, T₃ and T₄. The minimum water use efficiency was found minimum for treatment T₄.

Inference

It is suggested to implement treatment T₁ (120% RDF with 12 equal splits of RDF at interval of 10 days) for maximum yield and benefit cost ratio.

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