Assessment of Yield and Quality Traits of Tomato Hybrids Across Varied Planting Dates in Southern Telangana

ABSTRACT

This study evaluates the yield and quality traits of three tomato hybrids—US-440, PHS-448, and Heemsona—across varying planting dates under semi-arid conditions in Southern Telangana. Conducted at the Water Technology Centre, PJTSAU, Hyderabad, the research employed a Factorial Randomized Block Design, focusing on eight transplanting dates between March and October 2020. Significant differences were observed in several parameters, including average fruit weight, number of fruits per plant, total yield, and quality traits such as total soluble solids (TSS) and ascorbic acid content. The mid-October planting (D7) resulted in the highest average fruit weight (66.12 g) and yield (61.94 t ha^{-1}), highlighting this period as the most favorable for optimal productivity. Hybrid Heemsona consistently outperformed the others, achieving the highest yield (47.96 t ha^{-1}) and TSS (3.99° Brix), demonstrating its potential for both quantity and quality. However, the study revealed a trade-off between quality traits and yield, with TSS and ascorbic acid content inversely related to yield performance. Additionally, higher nitrogen uptake and dry matter production were linked to the D7 planting, stressing the importance of nutrient management during this critical planting window. The findings underscore the significance of selecting the appropriate planting date to enhance tomato production in semi-arid regions, providing valuable insights for growers aiming to balance yield and quality. This research offers practical guidance for optimizing tomato cultivation through strategic planting and hybrid selection.

KEYWORDS: Tomato hybrids, Planting dates, Yield traits, Quality traits, Semi-arid conditions, Heemsona

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most widely cultivated and economically significant horticultural crops globally, valued for its nutritional content and versatility in various food products, including sauces, pastes, and juices. Rich in vitamins A and C, lycopene, and antioxidants, tomatoes are highly sought after as both fresh produce and processed goods. As global demand increases, optimizing tomato production is vital, particularly in regions with challenging climates, such as Southern Telangana, India (Aklile et al., 2016; Arca et al., 2023). Southern Telangana experiences semi-arid conditions characterized by temperature fluctuations, humidity variations, and unpredictable rainfall. These environmental factors significantly impact tomato growth, yield, and quality. Farmers must focus on two critical elements to address these challenges: selecting high-yielding hybrids and optimizing planting dates (Hossain et al., 2017; Casals et al., 2021). Aligning planting schedules with favorable weather conditions during crucial growth stages—such as flowering, fruit setting, and maturation—enhances both yield and fruit quality (Ahammad et al., 2009; Nadia et al., 2018). Planting dates are particularly important in semi-arid regions due to tomatoes' sensitivity to temperature changes. Planting during extreme heat can result in poor pollination and low fruit set. Additionally, excessive heat or drought during fruit development can reduce fruit size and quality. Aligning planting dates with the local climate ensures optimal growing conditions, which is crucial for maximizing both productivity and fruit quality (Ghasemi et al., 2015; Titilayo et al., 2014). Choosing the right hybrid is equally essential in regions like Southern Telangana, where environmental stresses, including heat, drought, and diseases, can significantly affect crop performance. Drought-tolerant and heat-resistant hybrids can improve yield and fruit quality, addressing the challenges posed by water scarcity and high temperatures common in the region (Moraru et al., 2004; Waiba et al., 2021). Selecting suitable hybrids enables farmers to improve both production and profitability (Salwa et al., 2015). In addition to yield, hybrid selection affects quality traits like total soluble solids (TSS) and ascorbic acid content, which influence sweetness and nutritional value, respectively. Some hybrids may yield higher TSS and ascorbic acid but exhibit lower total yields, presenting a trade-off between quality and quantity. Farmers must balance these factors when selecting hybrids for specific market requirements (Shukla et al., 2021; Jamdhade, 2016). Research has shown that integrating optimized planting dates with appropriate hybrid selection can significantly improve tomato yields in challenging environments

(Jatav et al., 2017; Vijeth et al., 2018). Early planting, for instance, may exploit cooler temperatures to promote flowering and fruit development, while late planting may result in prolonged vegetative phases and reduced yields. Planting too late exposes crops to extreme heat, negatively impacting fruit quality and total yield (Panwar et al., 2021; Prakash et al., 2019). This study evaluates the yield and quality traits of three tomato hybrids—US-440, PHS-448, and Heemsona—planted at different times under semi-arid conditions in Southern Telangana. By analyzing factors such as average fruit weight, number of fruits per plant, total yield, and quality traits like TSS and ascorbic acid content.The research aims to identify optimal planting schedules and hybrids for this region. These findings offer valuable insights for farmers looking to enhance tomato production, contributing to sustainable and profitable agricultural practices in areas facing climatic challenges (Mounica et al., 2022; Noopur et al., 2021).

2. MATERIALS AND METHODS

The field experiment was conducted during 2020-21 at the Water Technology Centre, PJTSAU, Rajendranagar, Hyderabad, located at 17°19′ N latitude and 78°23′ E longitude, at an altitude of 542.3 m above mean sea level. The experimental site falls under the Southern Telangana agro-climatic zone and is classified as a semi-arid tropical region according to Troll's classification.

2.1 Experimental Design and Layout

The experiment was arranged in a Factorial Randomized Block Design (RBD), consisting of two factors: Factor I (eight transplanting dates) and Factor II (three tomato hybrids: US-440, PHS-448, and Heemsona). There were three replications for each treatment. The seedlings were transplanted on raised beds with dimensions of 0.8 m (width) × 8 m (length), with a distance of 0.4 m between beds. The crop was spaced using a paired row system with a distance of 40/80 cm × 60 cm between plants. Each experimental plot measured 3.6 m × 8 m. The seed rate for the tomato crop was 200 g ha^{-1}.

List 1: Treatmental details of the experiment

S.No	Treatments	
	Factor-1 Different dates of Transplanting	**Factor-2: Hybrids**

1	15th March -2020	H_1: US- 440
2	15th April-2020	H_2: PHS-448
3	15th June-2020	H_3: Heemsona
4	15th July-2020	
5	15th August-2020	
6	15thSeptember-2020	
7	15th October-2020	

2.2 Yield and Yield Attributes

The number of fruits per plant and the weight of fresh fruits were recorded at each picking. The total fresh fruit yield was calculated and expressed in tons per hectare (t ha^{-1}). Dry matter production was determined by drying plants from the sampling row uprooted at the first flower, 50% flowering, fruit initiation, first picking and last picking stages. The plants were shade dried and then oven dried at 60°C till constant weight was obtained. Afterward, the average dry matter production plant^{-1} was recorded and expressed in grams.

2.3 Biochemical parameters

Ascorbic acid (mg100g^{-1}) content of tomatoes was estimated by the volumetric method described by Sadasivam and Balasubramanian (1987).Total soluble solids were recorded with the help of a pocket refractometer and the average was worked out from all the five tomatoes.

2.4 Statistical Analysis

Data on different characters viz., growth and yield components and yield, were subjected to analysis of variance procedures as outlined for Factorial RBD (Gomez and Gomez, 1984). Statistical analysis was carried out using SAS. Statistical significance was tested by F–value at 0.05 level of probability and critical difference was worked out wherever the effects were significant.

3. RESULTS AND DISCUSSION

The study evaluated the effects of different planting dates on various yield and quality parameters of tomato hybrids in Southern Telangana, focusing on average fruit weight, number of fruits per plant, total yield, quality traits (TSS and ascorbic acid), nitrogen uptake, and dry matter production. The results demonstrated significant variability across planting dates and highlighted the importance of selecting the optimal planting period for maximizing yield and quality. Below is a detailed analysis of the findings:

3.1. Average Fruit Weight (g)

Planting dates significantly impacted the average fruit weight of the tomato hybrids. The highest average fruit weight was recorded in the D7 (Oct-15th) planting, with fruits averaging 66.12 g. This was followed by D8 (Nov-15th) and D6 (Sep-15th) plantings, indicating that mid-October was the most favorable period for achieving heavier fruits. Although no significant difference in fruit weight was observed among the hybrids, hybrid H3 – Heemsona demonstrated a consistent performance, aligning with findings by Cheena et al. (2018), which reported high fruit weights and overall yield when Heemsona was planted on September 15. Moreover, improvements in fruit weight, polar diameter, and equatorial diameter traits can significantly increase yield per plant, as noted by Maurya et al. (2020). This suggests that environmental conditions during the D7 planting period, such as optimum temperature *i.e.* 24-28^{o}c and favorable light intensity, may have contributed to enhanced fruit growth and development.

3.2 Number of Fruits per Plant

The number of fruits per plant was significantly influenced by planting dates. The D7 (Oct-15th) planting produced the highest number of fruits per plant (36.59), followed by D8 (Nov-15th) and D6 (Sep-15th). This suggests that planting in mid-October provided conditions that enhanced fruit set. Hybrid H3 – Heemsona consistently performed well across all planting dates, corroborating findings by Cheena et al. (2018), which noted optimal yields for Heemsona when planted around mid-September, resulting in 308.87 fruits per plant. Early planting, such as in July (D1), led to reduced yields, possibly due to adverse environmental conditions that negatively affected flower and fruit formation. This emphasizes the importance of optimal planting timing to ensure higher productivity.

3.3. Fruit Yield (t ha^{-1})

Total fruit yield was markedly affected by the planting dates, with D7 (Oct-15th) recording the highest yield of 61.94 t ha^{-1}. This was closely followed by D8 (Nov-15th) and D6 (Sep-15th), indicating that planting from mid-September to mid-November is ideal for maximizing yield in Southern

Telangana's semi-arid conditions. Hybrid H3 – Heemsona achieved the highest yield (47.96 t ha^{-1}) across all planting dates, attributed to its superior fruit set and average fruit weight. Previous research has shown that optimal transplanting dates are crucial for maximizing both yield and fruit quality, as seen in studies conducted in southern Andhra Pradesh (Madhumathi&Sadarunnisa, 2013). Furthermore, hybrids like EC-461070 × MTM Local have demonstrated high yield potential alongside desirable quality traits such as carotene content (Ebenezer, 2014). Early planting (D1 in July) proved less effective, resulting in substantially lower yields due to the potential for high temperatures and water stress during critical growth phases. This highlights the benefits of precise planting scheduling.

3.4. Total Soluble Solids (TSS) and Ascorbic Acid

Quality parameters, including TSS and ascorbic acid content, were significantly influenced by planting dates. D2 (April 15th) recorded the highest TSS (3.99° Brix) and ascorbic acid (32.89 mg/100 g), indicative of better flavor and nutritional quality. Hybrid H3 – Heemsona had a significantly higher TSS content compared to other hybrids, making it a suitable choice for markets that prioritize quality traits. The findings align with Singh et al. (2023), who reported that planting at optimal times, such as mid-September, helps avoid temperature extremes that can negatively impact sugar accumulation and quality. Similarly, Shravika et al. (2020) noted that precise scheduling of planting dates is essential for enhancing productivity and quality. The results underscore the need for proper scheduling of planting to optimize both yield and quality parameters, as TSS and ascorbic acid content are key indicators of tomato fruit quality. However, it is important to note that quality traits such as lycopene and ascorbic acid content were found to be negatively correlated with yield, suggesting a trade-off between quantity and quality (Rajesh Kumar et al., 2006).

3.5. Nitrogen Uptake

Nitrogen uptake was significantly influenced by planting dates. Higher nitrogen uptake was observed during D7 (Oct-15th) and D8 (Nov-15th) plantings, particularly at the fruit development and first picking stages. Hybrid H3 – Heemsona recorded the highest nitrogen uptake (26.3 kg ha^{-1} at fruit development and 40.4 kg ha^{-1} at first picking), suggesting its strong nutrient absorption capability. Although the interaction effect between planting dates and hybrids was not statistically significant, H3's superior nitrogen uptake likely contributed to its overall yield and dry matter production. Previous research by Moraru et al. (2004) supports the notion that optimal planting timing can positively influence nutrient uptake, which is critical for achieving better growth and productivity. Ensuring sufficient nutrient availability during critical growth phases can lead to better crop establishment and overall health.

3.6. Dry Matter Production

The study found that dry matter production varied significantly with planting dates, with the D8 (Nov-15th) planting yielding the highest values (36.8 g $plant^{-1}$ at fruit development and 75.5 g $plant^{-1}$ at first picking). Hybrid H3 – Heemsona also produced the highest dry matter (62.1 g $plant^{-1}$ at first picking), reinforcing its superior performance across planting dates. These results suggest that the environmental conditions during the D8 planting were ideal for dry matter accumulation, which directly influences crop quality and yield. Singh et al. (2023) emphasized that optimal planting dates provide favorable conditions for photosynthesis and biomass accumulation, supporting higher productivity. Moreover, timely planting allows for better resource use efficiency, including water and nutrients, which are crucial for sustained dry matter production and, subsequently, overall yield. Strategic planting timeframes, as suggested by Shravika et al. (2020), ensure that plants have the best possible conditions for growth, leading to improved dry matter and higher overall productivity.

4. CONCLUSION

This study highlights the importance of optimizing planting dates for maximizing tomato yield and quality in semi-arid zones. Mid-October (D7) was identified as the most favorable period, with Hybrid Heemsona (H3) consistently outperforming others in yield and fruit quality. These findings provide valuable insights for improving tomato production in Southern Telangana, emphasizing strategic planting to enhance productivity. Further research could explore interactions between planting dates, irrigation, and fertilization practices for comprehensive cultivation guidelines.

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Table 1 Yield attributes and yield of tomato

Treatments	Average fruit weight (g)	Number of fruits $plant^{-1}$	Yield ($t\ ha^{-1}$)
Date of Planting			
D1 (Mar -15th)	51.06	20.03	29.05
D2 (April-15th)	54.76	22.70	33.97
D3 (June -15th)	61.68	30.99	49.66
D4 (July -15th)	58.34	28.20	44.31
D5 (Aug -15th)	57.42	25.43	39.04
D6 (Sep -15th)	61.98	31.02	50.79
D7 (Oct -15th)	66.12	36.59	61.94
D8 (Nov-15th)	63.99	33.80	56.10
S.Em±	3.57	0.84	1.53
CD (P=0.05)	NS	2.39	4.35
Hybrids			
H1(US-440)	58.78	28.26	44.80
H2 (PHS-448)	58.52	28.06	44.06
H3 (Heemsona)	60.95	29.47	47.96
S.Em±	2.19	0.51	0.94
CD (P=0.05)	NS	NS	2.67
Interaction (A x B)			
S.Em±	6.18	1.45	2.65
CD (P=0.05)	NS	NS	NS

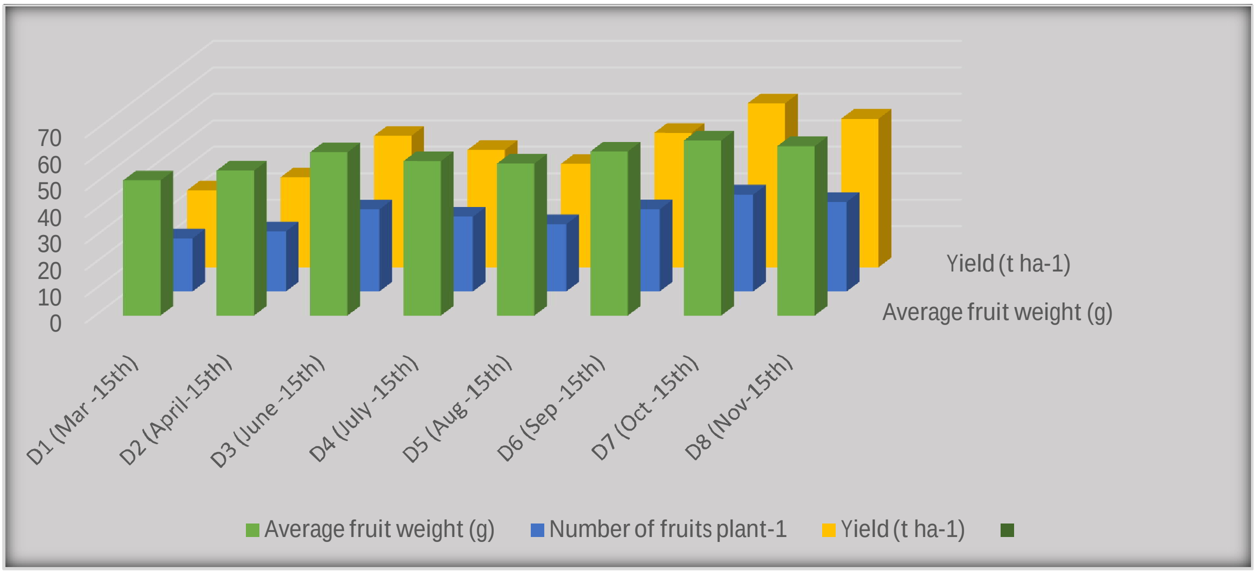

Fig 1. Yield attributes and yield of tomatounder different dates of planting

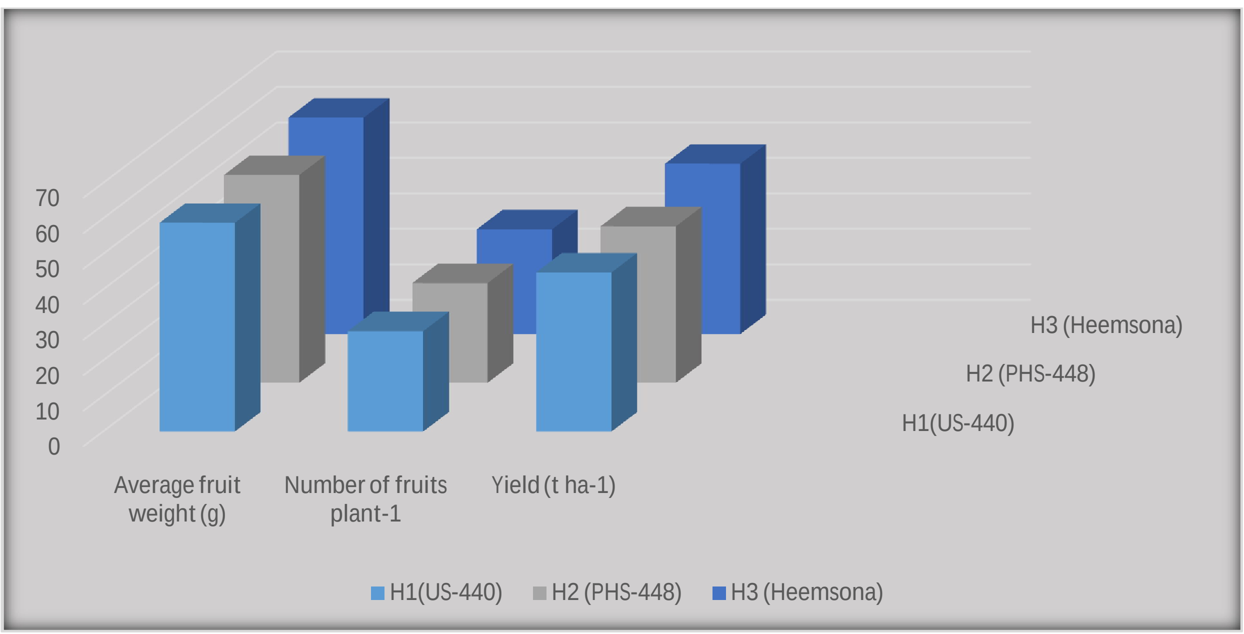

Fig 2. Yield attributes and yield of tomatoamong different hybrids

Table 2: TSS and Ascorbic acid at different stages of tomato

Treatments	TSS (° Brix)	Ascorbic acid (mg 100 g^{-1})
Date of Planting		

D1 (Mar -15th)	3.78	31.67
D2 (April-15th)	3.99	32.89
D3 (June -15th)	3.58	30.43
D4 (July -15th)	3.28	29.01
D5 (Aug -15th)	3.49	30.40
D6 (Sep -15th)	3.48	30.31
D7 (Oct -15th)	3.29	29.06
D8 (Nov-15th)	3.09	27.87
S.Em+	0.06	0.38
CD (P=0.05)	0.18	1.08
Hybrids		
H1(US-440)	3.48	**30.04**
H2 (PHS-448)	3.47	30.00
H3 (Heemsona)	3.55	30.58
S.Em±	0.04	0.23
CD (P=0.05)	0.11	NS
Interaction (A x B)		
S.Em±	0.11	0.66
CD (P=0.05)	NS	NS

Table 3: N uptake at different stages of tomato

Treatments	**Flower initiation**	**50% flowering**	**Fruit development**	**First picking**	**Last picking**
Date of Planting					
D1 (Mar -15th)	2.40	8.20	18.40	23.00	15.10

D2 (April-15th)	1.50	6.50	20.20	29.00	17.30
D3 (June -15th)	3.00	9.90	24.20	37.99	23.25
D4 (July -15th)	3.80	11.50	28.50	45.10	19.70
D5 (Aug -15th)	5.10	15.30	27.60	44.46	21.69
D6 (Sep -15th)	4.00	13.10	25.00	39.45	24.00
D7 (Oct -15th)	4.20	13.30	29.40	45.20	24.30
D8 (Nov-15th)	4.95	14.99	31.50	50.40	23.65
S.Em+	0.08	0.27	0.53	0.77	0.50
CD (P=0.05)	0.24	0.77	1.50	2.19	1.43
Hybrids					
H1(US-440)	3.61	11.59	25.31	38.89	20.90
H2 (PHS-448)	3.56	11.42	25.20	38.69	20.82
H3 (Heemsona)	3.68	11.79	26.29	40.40	21.65
S.Em±	0.05	0.16	0.32	0.47	0.31
CD (P=0.05)	NS	NS	0.92	1.34	NS
Interaction (A x B)					
S.Em±	0.15	0.47	0.92	1.33	0.87
CD (P=0.05)	NS	NS	NS	NS	NS

Table 4: Dry matter production at different stages of tomato

Treatments	**Flower initiation**	**50% flowering**	**Fruit development**	**First picking**	**Last picking**
Date of Planting					

D1 (Mar -15th)	3.45	9.42	18.57	37.89	29.87
D2 (April-15th)	1.99	6.86	22.59	45.99	34.40
D3 (June -15th)	4.29	11.25	26.77	58.99	49.85
D4 (July -15th)	5.18	12.44	31.93	68.35	39.15
D5 (Aug -15th)	6.99	14.96	32.69	68.99	43.78
D6 (Sep -15th)	6.02	13.54	27.60	60.99	52.01
D7 (Oct -15th)	6.12	13.65	31.75	67.14	52.23
D8 (Nov-15th)	6.96	14.81	36.77	75.45	50.99
S.Em$\pm$	0.278	0.375	0.58	1.26	1.16
CD (P=0.05)	0.792	1.066	1.66	3.58	3.29
Hybrids					
H1(US-440)	5.01	11.93	28.27	59.80	43.51
H2 (PHS-448)	4.91	11.90	28.12	59.51	43.38
H3 (Heemsona)	5.45	12.52	29.36	62.11	45.22
S.Em$\pm$	0.170	0.229	0.36	0.77	0.71
CD (P=0.05)	NS	NS	1.01	2.19	NS
Interaction (A x B)					
S.Em$\pm$	0.482	0.649	1.01	2.18	2.00
CD (P=0.05)	NS	NS	NS	NS	NS