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Evaluation of tomato hybrids under agro-climatic condition of Prayagraj (*Solanum lycopersicum* L.)

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Abstract
This study conducted the "Evaluation of Tomato Hybrids under Agro-Climatic Conditions of Prayagraj" at the Horticultural Research Field, SHUATS, Prayagraj, Uttar Pradesh during Rabi 2024-2025. Assessment of ten tomato hybrids was conducted under randomized block design with three replications at Horticultural Research Field, SHUATS, Prayagraj, Uttar Pradesh. The ten hybrids included TMTH-291, TMTH-241, TMTH-2256, TMTH-2241, TMTH-270, TMTH-222, TMTH-255, Aryaman, and Abhilash as a local check. The growth and yield parameters received observations for hybrid selection which best matched local agro-climatic zones. At day 90 after transplant (DAT), TMTH-2256 reached the maximum height of 102.1 cm while producing the greatest number of branches at 17.73 when compared with local check Abhilash which measured 91.7 cm in height and had 16.13 branches. The growth pattern of TMTH-275 was equally robust as it reached 95.8 cm in plant height with 16.40 branches. TMTH-2256 demonstrated a fast-flowering period of 27.07 days together with the most flowers per cluster (8.33) and fruits per cluster (6.40) indicating improved reproductive Vigor. TMTH-2256 generated the maximum yield based on both plant output (2.67 kg) and hectare assessment (88.87 t/ha) while TMTH-275 achieved 2.47 kg/plant yield and 82.18 t/ha yield. Based on economic analysis of TMTH-2256 achieved the best benefit-cost ratio which validated its potential for commercial markets. Genetic diversity exists among the evaluated genotypes which demonstrates their significant adaptability potential together with yield-producing differences. The Prayagraj agro-climatic conditions favoured TMTH-2256 as the leading hybrid followed by TMTH-275 which makes them promising commercial options in Uttar Pradesh.

Keywords: Tomato hybrids, plant height, number of branches, agro-climatic conditions, reproductive vigour, Prayagraj, growth parameters

Introduction
The self-pollinating tomato crop (*Solanum lycopersicum* L.) contains 12 chromosome pairs as a diploid species (2n = 24) and people grow them across approximately 3000 species worldwide. Among twelve wild species in the "Lycopersicon" genus stands the single domesticated tomato plant which is *Solanum lycopersicum*. Self-incompatible wild tomatoes show extensive genetic diversity through species like *Solanum chilense* and *Solanum peruvianum* which have their origin on South American land between the Andes and the Nile Sea (Jenkins, 1948). Raw salads contain ripe tomato fruits which serve as the base for various processed food products including paste, puree, powder and whole fruit cans and ketchup and sauce. The production of chutney and pickles starts with using unripe green fruits. Among all vegetable crops worldwide the tomato stands in second position behind potatoes, and it maintains the third position in India behind potatoes and onions. India ranked as the world's second-largest tomato producer and second largest holder of tomato cultivating land after China. The National Horticultural Board reports that India produces tomatoes on 0.81 million hectares through which 20.51 million tons are obtained each year at 21.13 t/ha productivity (NHB, 2018-19). Due to its impressive heterosis capabilities the tomato can achieve uniform growth alongside resistance traits alongside overall better production and earlier maturation. Hybrid tomato varieties produced from high input agricultural systems will continue to dominate the market while showing potential expansion in specific lower input systems that demonstrate advantages. The commercial approval of new hybrids depends on their performance exceeding existing cultivated varieties.

Total production combined with early yield and nutritional quality along with post-harvest life and adaptability and resilience to insects and pests and diseases together with exterior appearance showcase this superiority. Scientific investigations indicate that tomato Vigor yield outperforms commercial varieties by achieving 300 percent increased production. Research studies show that 263 percent of Indian crops have chosen the superior parent through crossing. Choosing suitable tomato hybrids presented problems for farmers because they lacked control over the continuous introduction of new hybrid varieties alongside the uncertainty of getting the correct variety on time. The development of appropriate hybrid cultivars produced in the country helps reduce seed supply uncertainties. Scientists have established hybrid tomato development as an effective procedure to increase yield production. Total production combined with early yield quality and nutritional qualities alongside post-harvest durability and insect and disease resistance, adaptability, appearance quality, etc. represent superior attributes. This hybrid cultivation method represents a promising way to boost Uttar Pradesh's total tomato yield output. The tropical climate with its warm and humid characteristics creates various abiotic and biotic stress issues throughout the state. The increase of tomato production in Uttar Pradesh demands the identification of suitable hybrid cultivars for local agricultural environments.

Materials and methods

A research investigation titled "Evaluation of Tomato hybrids under agro-climatic conditions of Prayagraj (*Solanum lycopersicum* L.)" was performed in Rabi 2024-2025 in the Horticultural Research Field within the Department of Horticulture at Naini Agricultural Institute which operates under Sam Higginbottom University of Agriculture, Technology, and Sciences, Prayagraj, Uttar Pradesh. This study assessed ten hybrids including TMTH-291, TMTH 241, TMTH 2256, TMTH 2241, TMTH 270, TMTH 222, TMTH 255 the analysis consisted of nine hybrids versus one local check using a randomized block design with each treatment implemented three times. The evaluation of ten hybrids TMTH-291, TMTH 241, TMTH 2256, TMTH 2241, TMTH 270, TMTH 222, TMTH 255, Aryaman, and Abhilash (check) included measurements of Plant height (cm), No. of primary and secondary branches, flowers per cluster, fruits per cluster, flowers cluster per plant, Days taken to first flowering, Days taken for 50% flowering, Days taken to first harvesting, Average fruits weight (gm.), No. of fruits per plant, Fruit yield per plant (kg), Fruits yield per hectare (tonnes), and Economics. The seedlings reached 30 days in age before getting planted in the field with both 60 cm between rows and 45 cm between plants.

Results and discussion. Growth Parameter Plant height (cm)

The plant height (cm) measurements at 30 days after transplanting showed ABHILASH (33.7) had the lowest value and TMTH 2256 (44.0) achieved the highest value while the mean plant height reached 38.0 cm. Among the experimental hybrids TMTH 2256 achieved the tallest plant height of 44.0 cm followed by TMTH 275 42.2 cm. The check ABHILASH (33.7 cm) shared a similar plant height range with four hybrids consisting of TMTH 241 (38.7 cm), TMTH 270 (38.6 cm), TMTH 222 (38.3 cm), and TMTH 291 (37.7 cm). The plant height (cm) at 60 days after transplanting showed a range from 56.5 (ARYAMAN) to 66.2 (TMTH 2256) with an average of 60.8 cm. The check hybrid ABHILASH measured plant height (57.0 cm.) The highest plant height was recorded in hybrids TMTH 2256 (66.2) while TMTH 275 (65.2) placed second. Among the evaluated hybrids TMTH 291 (61.0) and TMTH 270 (61.7) and TMTH 222 (60.9) along with TMTH 255 (60.2) demonstrated comparable plant heights to the check ABHILASH (57.0). The plant height (cm) measurement at 90 days after transplanting revealed a minimum of 84.6 cm in ARYAMAN and a maximum of 102.1 cm in TMTH 2256. The mean value was 93.2 cm. The check variety ABHILASH reached a maximum plant height of 91.7 cm at 90 days after sowing. TMTH 2256 (102.1 cm) displayed the maximum plant height among the evaluated hybrids which was closely followed by TMTH 275 (95.8 cm) and TMTH 222 (95.8 cm). The evaluation of hybrid tomato revealed TMTH 241 (93.9), TMTH 291 (92.0), TMTH 270 (91.3), and TMTH 255 (94.6) showed equal performance to the ABHILASH check (91.7). Plant height serves as an effective indicator of plant health which lead to higher production potentials. Plant height could change because of indeterminate or semi determinate growth patterns together with genetic diversity. It confirms the findings of Mounica *et al*., (2022) [9]. Similar observation was also made by Kumar *et al*. (2018) [13], Parmar *et al*. (2018) [11] in different tomato cultivars.

No. of Primary & branches

The assessment at 30 days after sowing revealed 4.69 branches per plant as the mean value which ranged between 4.20 (TMTH 255) and 6.13 (TMTH 2256). The check variety ABHILASH showed an average of 4.53 plant branches among its plants. TMTH 2256 displayed the maximum number of branches at 6.13 while TMTH 275 and TMTH 241 demonstrated 5.20 and 5.00 branches per plant respectively. Three hybrids TMTH 291 (4.33), TMTH 270 (4.53), and TMTH 2241 (4.33) exhibited branch numbers comparable to the check variety ABHILASH (4.53). The number of plant branches reported at 60 days after sowing measured from 10.33 for Abhilash to 12.33 for TMTH 2256 with an average of 10.85 branches per plant. Abhilash (check) plants displayed 10.33 branches for each of its plants. Results indicated TMTH 2256 as the variety with the highest number of branches at 12.33 followed by TMTH 275 and TMTH 241 with 11.27 and 11.07 branches respectively. The hybrid varieties TMTH 291 (10.60), TMTH 2241 (10.47), TMTH 270 (10.73), TMTH 222 (10.60), and TMTH 255 (10.40) displayed branch number densities similar to those of the check variety Abhilash (10.33). The number of branches per plant reached a maximum of 17.73 in TMTH 2256 while reaching a minimum of 14.47 in TMTH 222 during assessment at 90 DAT. The analysis indicated an average of 15.73 branches per plant. The experimental check Abhilash demonstrated 16.13 plant branches which aligned closely with the varieties TMTH 275 (16.40) and ARYAMAN (16.20) in terms of branching numbers per plant. The highest number of plant branches was observed in TMTH 2256 at 17.73 followed by TMTH 275 at 16.40. The study confirms previous observation by Sarmah *et al*. (2024) [14]. Similar finding was matched the data reported by Kumar *et al*. (2017) [21].

Yield parameters Days to first flowering

The minimum mean number of days to initial flowering occurred in ten tomato hybrids was determined. TMTH 2256 reached its first flowering state after 27.07 days whereas TMTH 270 required 30.87 days indicating delayed flowering behaviour. The total average flowering duration for all hybrids amounted to 28.85 days. The check hybrid Abhilash underwent flowering at 28.67 days on average whereas TMTH 270 required 2.2 additional days to blossom. The harvest of tomatoes at early stages results in superior productivity compared to delayed harvesting periods. This research supports the results documented in Mounica *et al*. (2022) [9]. Singh *et al*. (2014) [19] along with Lekshmi and Celine (2015) [8] and Raja Naik *et al*. (2018) [10] documented comparable day-to-flowering durations in their research of diverse tomato hybrid types.

Days to 50% flowering

The tomato hybrid TMTH 2256 reached 50% flowering the earliest at 41.07 days while ARYAMAN recorded the longest period of 46.40 days indicating delayed flowering. All tomato hybrids showed an overall average (par value) time to flowering of 44.03 days. The check hybrid Abhilash flowered in 42.20 days while ARYAMAN's flowering period reached 46.40 days which indicates a delay of 4.2 days longer than the check hybrid. A comparable range of days to 50% blooming was documented by Rojalin *et al*. (2019) [22] across different tomato cultivars.

No. of flowers per cluster

The number of flowers per cluster within the experimental tomato hybrids showed TMTH 255 yielded mean value of 5.27 flowers as the minimum while TMTH 2256 achieved the maximum mean of 8.33 flowers. The total mean value across all hybrids measured 6.44. TMTH 2256 surpassed the check hybrid Abhilash by 1.80 flowers per cluster based on its mean value of 6.53 flowers per cluster. Favourable weather conditions lead hybrid seeds to develop increased yields when more flower clusters appear on each plant. These research results support the observations from Mounica *et al*. (2022) [9]. The research by Cheema *et al*. (2013) [23] along with Hossain *et al*. (2014) demonstrated identical outcomes regarding flower cluster counts in tomato hybrids.

No. of fruits per cluster

The number of fruit clusters observed in tomato hybrids varies because of the maximum number of fruit setting potential within each hybrid. An assessment of different tomato hybrid clusters revealed TMTH 255 had the least average number of fruits at 3.73 per cluster and TMTH 2256 maintained the most at 6.40 fruits per cluster. All hybrids combined produced an average of 4.61 fruits per cluster. The data indicates TMTH 2256 produced noticeably more fruits per cluster than check hybrid Abhilash because it surpassed Abhilash's 4.47 fruits per cluster with 1.93 additional fruits per cluster. Prasad *et al*. (2019) [12] supported these results which align with previous research by and Cheema *et al*. (2013) [23] in hybrid tomatoes.

No. of flower cluster per plant

Flower cluster number on each plant represents a key factor for determining total yield quantity. A higher cluster number per plant typically results in higher fruit production under favourable environmental conditions. The flower cluster data showed TMTH 291 had a minimum count of 13.40 clusters per plant, TMTH 2256 achieved a maximum count of 16.80 clusters per plant which reflected its advanced flowering capabilities. The average flower cluster count throughout all hybrids amounted to 14.67. TMTH 275 showed the second-best performance as a hybrid with 15.93 flower clusters per plant while TMTH 241 and ARYAMAN reported 14.93 clusters per plant. The check hybrid Abhilash exhibited a mean of 14.47 flower clusters per plant but performance data from TMTH 2256 and TMTH 275 revealed superior outcomes. Higher numbers of flower clusters per plant below optimal conditions could potentially lead to increased numbers of fruits per plant. Various researchers including Rojalin *et al*. (2019) [22] have reported findings similar to these observations.

Days taken for first harvesting

According to the information collected on the number of days until the first harvest of the tomato hybrids, TMTH 2256 had the earliest potential for harvesting with the lowest mean value of 85.33 days, while TMTH 291 had the highest mean value of 94.47 days, indicating a comparatively longer crop duration. All hybrids had a mean (par value) of 90.70 days. The early or late maturity is attributed to genotypic characteristics and partially influenced by the environmental factors of any given growing area, in contrast to the check hybrid Abhilash, which took 88.07 days to reach first harvest. This finding was confirmed by Mounica *et al*., (2022) [9]. Similar findings were observed by Sharma and Sharma (2012) [15].

Average fruit (gm)

Significant variation was found among the genotypes based on the average fruit weight data for the tomato hybrids under evaluation. In comparison to the other hybrids, TMTH 222 had the smallest mean fruit weight, weighing 52.78 g. Given their potential to produce larger and more marketable fruits, TMTH 2256 had the highest mean fruit weight (88.00 g), closely followed by TMTH 275 (86.75 g). All hybrids combined had a mean (par value) of 79.02 g. Compared to TMTH 2256 and TMTH 275, the check hybrid Abhilash had a lower average fruit weight of 83.69 g. Fruit weight and fruit number per plant are generally inversely correlated, despite the fact that both of these characteristics are key factors influencing yield. Customers or market choice determine the fruit weight, which is a function of fruit size (fruit length and girth). This finding was confirmed by Mounica *et al*., (2022) [9] in tomato hybrids.

No. of fruits per plant

With a mean of 23.13, TMTH 291 recorded the lowest collected production of fruits potential among all the evaluated tomato hybrids. TMTH 2256 recorded the highest mean value of 30.33 fruits per plant, followed by TMTH 275 with a second highest mean of 28.40, therefore showing better yield capacity in these hybrids. The par value among all the hybrids was 25.94. The check hybrid Abhilash had an average of 26.80 fruits per plant. These results show that for more fruit yield per plant than the check, TMTH 2256 and TMTH 275 are worth-considering hybrids. Variation in number of fruits per plant was attributed to genetic composition of the hybrids since all the hybrids tested were exposed to nearly similar kind of cultural atmospheric and edaphic conditions. This finding was reported by Mounica *et al*., (2022) [9]. Similar findings were also reported by Singh *et al*. (2014) [19], Cheema *et al*. (2013) [23], Parmar *et al*. (2018) [11] noted variability in number of fruits per plant in tomato hybrids.

Yield per plant (kg)

The productivity analysis established that TMTH 222 produced the minimal mean yield of 1.40 kg per plant while other entries displayed higher results. Among the evaluated tomato hybrids TMTH 2256 demonstrated the highest mean yield at 2.67 kg per plant while TMTH 275 obtained the second-highest mean yield of 2.47 kg per plant. Total plant yield across all hybrids maintained an overall mean of 2.05 kilograms per plant. In yield performance, the check hybrid Abhilash yielded 2.24 kg per plant which performed better than the par value yet trailed behind TMTH 2256 and TMTH 275. The research indicates that TMTH 2256 and TMTH 275 offer promising opportunities to boost tomato fruit production within breeding programs. Similar results were documented by Mounica *et al*. (2022) [9] as well as Dhillon *et al*. (2019) [24].

Fruit yield (tonnes) per ha

The research evaluated tomato hybrids at TMTH 222 for its lowest mean yield reaching only 46.69 tonnes per hectare. The maximum mean yield among tested tomato hybrids was achieved by TMTH 2256 with 88.87 tonnes per hectare followed by TMTH 275 which produced 82.18 tonnes per hectare. Statistical analysis showed that all the tested hybrids yielded an average of 68.24 tonnes per hectare. The check hybrid Abhilash reached 74.81 tons per hectare while exceeding the par value however producing lower yields than top-performing hybrids. The yield potential in tomato cultivation indicates excellent prospects for both TMTH 2256 and TMTH 275 hybrid varieties. Each individual tomato hybrid displays its maximum production potential through fruit yields which assess its capabilities at the single plant level. The highest number of fruits produced by tomato hybrid plants occurred because these plants set more flowers and maintained more ripe fruits during the production cycle. The findings presented by Mounica *et al*. (2022) [9] validated these results. The research of Cheema *et al*. (2013) [23] all demonstrated identical results.

Economics

Data pertaining to economics indicated that the cost of cultivation for the hybrids Abhilash check (Rs.93956.00) followed by Aryaman (Rs.92956.00), TMTH 2256 (Rs. 92256.00) was recorded with the lowest cost of cultivation. It was found that cultivation of TMTH 2256 (T7) gave higher net returns of Rs. 529306.00 per ha as compared to hybrid TMTH 275 (T3) Rs 482663.00, Hybrid Abhilash (check) gave net return of Rs. 429716.54, the lowest net return was recorded in hybrid TMTH 222 (Rs. 234545.84). Similarly, TMTH 2256 (T7) was recorded with highest benefit cost ratio of 5.71 Followed by TMTH 275 T3 (5.21), Abhilash check (T6) recorded with lowest B:C ratio of 2.54

Table 1: Mean performance of tomato hybrids and standard check for growth attributes

S.N	Treatment	Plant height (cm)			No. of primary & secondary branches			Days to first flowering	Days to 50% flowering	Flower per cluster	Fruits per cluster	Flower cluster per plant
		At 30 DAT	At 60 DAT	At 90 DAT	At 30 DAT	At 60 DAT	At 90 DAT					
1	TMTH 291	37.7	61.0	92.0	4.33	10.60	15.27	29.93	45.07	6.27	4.20	13.40
2	TMTH 241	38.7	60.5	93.9	5.00	11.07	15.80	28.67	44.27	6.67	4.67	14.93
3	TMTH 275	42.2	65.2	95.8	5.20	11.27	16.40	28.73	44.20	7.27	5.40	15.93
4	ARYAMAN	33.9	56.5	84.6	4.27	10.67	16.20	29.07	46.40	6.27	4.27	14.93
5	TMTH 2241	36.1	58.5	89.9	4.33	10.47	15.00	27.73	42.07	6.53	4.60	13.47
6	ABHILASH	33.7	57.0	91.7	4.53	10.33	16.13	28.67	42.20	6.53	4.47	14.47
7	TMTH 2256	44.0	66.2	102.1	6.13	12.33	17.73	27.07	41.07	8.33	6.40	16.80
8	TMTH 270	38.6	61.7	91.3	4.53	10.73	14.87	30.87	44.73	5.67	4.27	13.87
9	TMTH 222	38.3	60.9	95.8	4.40	10.60	14.47	29.40	46.13	5.60	4.07	14.73
10	TMTH 255	37.3	60.2	94.6	4.20	10.40	15.40	28.40	44.13	5.27	3.73	14.13
Mean		38.0	60.8	93.2	4.69	10.85	15.73	28.85	44.03	6.44	4.61	14.67
S. Em (±):		2.05	1.94	1.49	0.17	0.15	0.10	0.94	1.10	0.15	0.18	0.56
CD(P = .05)		6.09	5.76	4.41	0.51	0.46	0.31	2.78	3.27	0.46	0.53	1.67

Table 2: Mean performance of tomato hybrids and standard check for yield attributes

S.N	Treatment	Days to first fruit harvesting	No. of fruits per plant	Average fruit weight (gm.)	Fruits yield per plant (kg)	Fruits yield per ha.(tonnes)
1	TMTH 291	94.47	23.13	77.61	1.79	59.83
2	TMTH 241	89.53	24.87	84.61	2.10	70.05
3	TMTH 275	86.07	28.40	86.75	2.47	82.18
4	ARYAMAN	94.13	24.53	78.01	1.91	63.79
5	TMTH 2241	93.53	25.73	80.62	2.00	66.75
6	ABHILASH	88.07	26.80	83.69	2.24	74.81
7	TMTH 2256	85.33	30.33	88.00	2.67	88.87
8	TMTH 270	89.27	24.60	78.29	1.93	64.18
9	TMTH 222	93.63	26.53	52.78	1.40	46.69
10	TMTH 255	92.97	24.47	79.81	1.96	65.25
Mean		90.70	25.94	79.02	2.05	68.24
S. Em (±):		2.00	0.94	0.49	0.07	2.32
CD(P = .05)		5.96	2.78	1.46	0.21	6.89

Conclusion

Overall, TMTH 2256 emerged as the best-performing variety across a wide range of growth, flowering, yield, and quality parameters, making it the most promising cultivar for high productivity and quality in tomato cultivation. Its early flowering and harvesting, along with high yield and good fruit quality traits with high net return and B:C ratio it suggests that TMTH 2256 would be an ideal choice for farmers aiming for both higher economic returns and efficient crop management.

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