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Evaluation of tomato (*Solanum lycopersicon* L.) genotypes for growth, yield and quality traits

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Abstract
A field experiment on "Evaluation of tomato genotypes for ToLCV resistance, yield and yield attributing traits" was conducted at the experimental block of the Department of Vegetable Science, College of Horticulture, Bagalkote during *summer* season 2022. Fifty-three tomato genotypes including *Solanum pimpinellifolium* accessions, selected hybrids and their parents along with the released varieties were evaluated under natural field condition by adapting randomized block design with two replications. Among which LP 9 recorded the maximum number of branches per plant and highest plant height. LP 8 and LP 12 were earliest to flower, LP 15 recorded maximum flowers per cluster, fruits per cluster and fruits per plant, average fruit weight was maximum in HUB 3 × DMT 2, polar diameter was maximum in HUB 43 × DMT 2 and maximum equatorial diameter was reported in HUB36 × Arka Meghali. Highest yield was recorded in HUB 46 × Arka Vikas and HUB 43 × DMT 2, highest pericarp thickness and TSS in HUB 36 × DMT 2 and HUB 36 respectively, maximum number of locules per fruit were recorded in the genotype HUB 13 × Arka Meghali.

Keywords: Growth, yield, evaluation, genotype

Introduction
Tomato (*Solanum lycopersicum* L.), a fruit that is universally regarded as a vegetable and a perennial plant belonging to the Solanaceae family that is typically grown as an annual. It is a popular vegetable grown all over the world and is thought to have originated in the Andean area which includes portions of Colombia, Ecuador, Peru, Bolivia and Chile. The wild tomato (*Lycopersicon esculentum* var. *cerasiforme*) is thought to be the ancestor of the cultivated tomato (*Solanum lycopersicum* L.).

Although *Solanum lycopersicum* is a day-neutral self-pollinated crop it does experience some amount of cross-pollination. It is one of the most versatile crops in the world because of its fast and wide climatic adaptation. Tomato is the world's most popular and widely cultivated vegetable crop and grown in all kinds of climate *viz.*, temperate, subtropical and tropical. Tomato is an integral element of everyone's daily diet in India and world and every vegetable dish is incomplete without it. It is most commonly consumed as a fresh vegetable or salad as well as in processed forms such as paste, juice, sauce, ketchup and powder or as a whole peeled tomato (Toor and Savage, 2005) [23]. Tomatoes which were once thought to be harmful are now gaining favour among consumers. Based on its importance tomato is known as "Golden apple" or "Love apple" in England.

Because of its high nutritional value, tomato is also considered as a protective food. It contains 15 to 35 mg of vitamin C per 100 g of fruit as well as a high level of vitamin A and other nutrients. It has commercial potential as a source of tomatine which ranges from 130 to 150 mg per 100g of fresh tomatoes. Tomatine is a steroidal hormone that can be used to replace diosgenin. Several epidemiological studies have shown that consumption of tomato protects against cancer of digestive tract, stomach, colon, rectum and this beneficial effect is due to presence of antioxidant compounds such as lycopene, β carotene and vitamin C. It has become more popular all over the world because of a good source of vitamins A and C, solids content, good taste and fruit set even at high temperature (Prema *et al.*, 2011) [17].

Globally tomato cultivation spans over an area of 5.51 million hectare with a production of 186 million tonnes and productivity of 37.10 metric tonnes (Anon, 2021a) [4]. In India, tomato is cultivated in an area of 0.81 million hectare with an annual production of 21.17 million tonnes and productivity 25.32 metric tonnes per hectare. Karnataka occupies a third place in the country with an area of 64.25 thousand hectares and production of 2081 thousand tonnes with an average productivity of 32.40 tonnes per hectare (Anon, 2021b) [5].

Since the mid-nineteenth century, tomato farming has been increasingly popular due to the ability to grow tomatoes all the year. So far, breeding efforts have resulted in amazing improvement in tomato yield and quality traits and as a result of these efforts hundreds of novel cultivars and hybrids have been developed over the last 50 years to fulfil the numerous needs and climates in which tomato is grown.

Yield is a complex character which is impacted by a large number of other characters and their interactions. A study of correlation between various quantitative characters provides the magnitude of association of different characters with yield, assessing direct and indirect contribution of various components to yield and aiding the selection programme for better gains, so it is important to know the growth, yield and yield attributing traits of the genotypes to know their potentiality.

Materials and Methods

The experiment was undertaken at experimental block of Department of Vegetable Science, College of Horticulture Bagalkot, during *summer* season of 2022 and the quality parameters measurement, biochemical analysis and molecular work were carried out in vegetable science and biotechnology department laboratory. Field is located in the Northern Dry Zone of Karnataka, at an elevation of 533 metres above mean sea level (MSL), at 16'18' N latitude and 75' 07 E longitude (Zone-3). The soil in the experiment area is red sandy loam soil (Alfisols) with a homogeneous fertility

Raising of healthy seedlings and Planting: Tomato seeds were sown in pro-trays having 98 cells. Regular irrigation and plant protection measures were taken to raise the good quality seedlings using growing media i.e. Mixture of cocopeat and farm yard manure in 2:1 ratio. Portrays were kept in net house to avoid incidence of whitefly which spread the leaf curl disease. The 30 days old seedlings were transplanted at the spacing of 75 × 60cm and provided irrigation and nutrients as per package of practices. The experimental field was kept free from weeds by hand weeding once in 30 days. At an interval of 6-7 days, required number of irrigations were given during the entire period of experimentation. Staking facilitates intercultural operations, support to plants and helps in maintaining quality of fruits. So, it is done 2-3 weeks after transplanting. Staking is done with the help of wooden stakes and laying overhead wires, to which individual plant is tied.

The growth parameters were timely recorded and for harvesting fruit becomes ready for first picking in about 60-70 days after transplanting. Fruits are normally harvested early in the morning. The fruits are harvested by twisting motion of hand to separate fruits from the stem and harvested fruits kept in crates in shade. Tomato fruits are harvested at an interval of 3-4 days.

Field data were collected in this experiment, including growth parameters, plant characters, yield components and fruit yield of tomato plant, as indicated next. Plant height (cm): Plant height was recorded by measuring the height of randomly selected plants in each plot from the ground level to the main apex; mean values were expressed in cm. Number of primary branches: Number of primary branches per plant were counted at the maturity stage and means were computed. Days to 50% flowering: The number of days was noted from transplanting date to the day on which 50% of the plants in a plot flowered. Number of flowers per flower cluster: Tomato plants were tagged from each plot for this purpose and the numbers of flowers were counted from lower, middle and upper clusters; the mean number of flowers per cluster was computed. Number of fruit clusters per plant: The number of fruit clusters per plant was counted from the pre-tagged plants. Number of fruits per cluster: The total number of fruits per clusters was counted from each pre-tagged plant in each plot having three labels hung on lower, middle and upper parts. Days to first harvest: Number of days from transplanting date to first picking day was counted. Average fruit yield per plant (kg/plant): This was measured by taking the mean weight of fruit in successive harvests per plant and expressed in kg per plant. Average number of fruits per plant: The mean number of fruits per plant was calculated by counting the number of fruits of successive harvests per plant

Statistical analysis

For statistical analysis Randomized Complete Block Design was adopted

Results and Discussion

Table 1: Evaluation of tomato genotypes for growth, yield and quality parameters

Sl. No	Genotypes	Plant height (cm)	Number of primary branches	Number of flowers/clusters	Average fruit weight (g)	Number of fruits per plant	Polar diameter (cm)	Equatorial diameter(cm)	Yield/plant (kg)	Pericarp thickness (mm)	Number of locules	TSS (°B)
1	HUB 2	58.40	3.40	3.83	29.04	24.47	3.50	3.31	0.71	3.47	3.27	3.84
2	HUB 3	65.00	2.60	3.63	19.87	13.83	2.33	2.41	0.27	3.43	3.19	3.47
3	HUB 6	68.70	3.80	3.47	34.07	24.32	3.34	3.52	0.83	3.87	3.03	3.86
4	HUB 13	83.00	4.20	3.37	27.07	30.98	3.19	3.31	0.84	3.47	3.10	3.58
5	HUB 30	75.40	3.10	3.83	31.40	13.73	3.24	3.51	0.43	3.68	3.10	3.85
6	HUB 32	67.90	3.80	3.73	26.31	35.01	3.25	3.23	0.92	3.56	3.03	4.29
7	HUB 36	74.40	3.80	3.63	24.45	23.88	3.35	3.51	0.58	3.66	3.07	4.32
8	HUB 43	83.40	4.10	3.63	40.31	22.97	3.76	4.26	0.93	3.60	3.17	3.79
9	HUB 46	80.40	4.10	3.70	30.92	21.71	3.36	3.52	0.67	3.89	3.33	3.94
10	LP1	70.20	4.30	4.23	7.27	40.94	1.38	1.47	0.36	3.50	3.21	3.66
11	LP8	132.90	6.20	4.80	7.34	58.63	1.72	1.79	0.43	3.29	3.22	3.98
12	LP9	138.80	8.00	5.00	5.05	59.39	0.97	1.01	0.30	3.40	3.70	4.15
13	LP10	82.80	5.40	3.60	8.23	57.33	1.60	1.71	0.47	2.72	3.27	4.12
14	LP12	75.70	4.10	4.07	8.71	59.38	1.47	1.71	0.52	3.16	3.30	4.10
15	LP13	91.90	5.00	4.30	7.17	75.77	1.52	1.50	0.54	3.28	3.27	4.27

16	LP15	80.40	5.30	4.90	7.76	85.14	1.57	1.60	0.66	3.20	3.17	3.89
17	LP16	86.90	5.30	3.90	8.73	65.36	1.57	1.63	0.57	3.39	3.27	4.17
18	LP17	69.90	4.20	4.37	8.19	74.28	2.09	2.81	0.61	2.91	3.00	4.18
19	LP18	82.50	5.60	3.70	8.37	75.08	1.68	1.70	0.63	2.66	3.03	3.88
20	PKM1	66.70	4.10	3.67	31.73	19.58	3.80	4.00	0.62	3.40	3.07	3.65
21	Arka Abhed	81.80	3.90	3.67	35.35	21.94	3.76	3.90	0.78	3.66	3.20	3.46
22	Krishnaprabha Baari	68.20	4.20	3.83	39.18	19.75	3.25	3.52	0.77	3.54	3.17	3.41
23	HUB 2 × Arka Vikas	72.20	3.80	3.83	26.56	26.19	3.47	3.74	0.69	3.58	3.07	3.47
24	HUB 2 × DMT 2	73.50	3.90	3.87	28.84	25.07	4.04	4.29	0.72	3.88	3.40	4.01
25	HUB 2 × Arka Meghali	61.40	3.70	3.73	29.08	22.23	3.22	3.55	0.64	3.91	3.20	3.86
26	HUB 3 × Arka Vikas	74.90	4.10	4.13	22.02	33.52	3.48	3.68	0.73	4.06	3.10	3.92
27	HUB 3 × DMT 2	72.00	3.70	3.90	46.91	11.73	3.51	3.60	0.55	3.89	3.20	3.51
28	HUB 6 × Arka Vikas	75.90	4.60	4.03	32.49	22.23	3.31	3.48	0.72	3.78	3.07	3.62
29	HUB 6 × DMT-2	66.10	3.80	3.90	24.21	38.46	3.85	4.24	0.93	3.89	3.13	3.72
30	HUB 6 × Arka Meghali	73.30	4.50	4.30	25.74	43.93	3.84	4.21	1.13	4.05	3.24	3.61
31	HUB 13 ×Arka Vikas	81.30	4.00	3.93	25.97	34.44	3.29	3.66	0.89	3.83	3.53	3.56
32	HUB 13 × DMT 2	77.30	4.20	4.33	26.56	38.63	3.70	3.47	1.02	3.93	3.27	3.44
33	HUB 13 × Arka Meghali	81.80	4.40	4.00	27.89	34.27	4.08	4.16	0.96	4.03	4.00	3.40
34	HUB 13 × C	59.60	3.40	4.17	25.08	32.23	3.96	4.27	0.81	3.84	3.13	3.31
35	HUB 30 × Arka Vikas	77.60	4.10	4.10	30.45	31.50	3.85	4.21	0.95	3.80	3.17	3.34
36	HUB 30 × DMT-2	72.50	3.70	3.90	29.06	27.57	3.82	4.29	0.80	3.89	3.37	3.39
37	HUB 32 × Arka Vikas	70.20	4.10	4.10	23.24	30.31	3.39	4.01	0.70	3.76	3.07	3.66
38	HUB 32 × DMT 2	70.90	4.30	4.17	32.61	37.48	3.36	3.65	1.22	3.72	3.33	3.46
39	HUB 32 × Arka Meghali	65.30	4.10	4.07	23.49	31.09	3.72	4.22	0.73	3.84	3.30	3.61
40	HUB 36 × Arka Vikas	75.70	4.10	4.10	22.42	37.13	3.72	3.96	0.82	3.95	3.17	3.75
41	HUB 36 × DMT 2	63.90	3.60	3.97	26.45	36.18	3.62	3.77	0.96	4.13	3.07	3.61
42	HUB 36 × Arka Meghali	78.90	4.20	4.10	33.59	35.99	4.19	4.77	1.21	4.08	3.00	3.91
43	HUB 43 × Arka Vikas	71.70	4.30	4.23	31.55	30.12	3.60	4.16	0.95	3.88	3.03	3.49
44	HUB 43 × DMT 2	73.60	4.10	3.87	26.60	57.62	4.75	4.30	1.54	4.03	3.07	4.12
45	HUB 43 × Arka Meghali	76.40	4.20	3.97	33.75	43.34	3.76	3.94	1.46	4.10	3.10	4.22
46	HUB 43 × C	79.40	4.20	4.13	39.98	34.67	4.74	4.67	1.38	3.83	3.18	3.97
47	HUB 46 × Arka Vikas	84.90	4.50	4.13	31.26	51.15	4.08	4.32	1.57	3.67	3.15	4.06
48	HUB 46 × DMT 2	75.90	4.00	4.13	42.39	33.95	4.44	4.21	1.44	3.66	3.10	3.98
49	HUB 46 × Arka Meghali	82.00	4.90	3.97	37.03	29.87	3.92	4.30	1.11	3.91	3.13	3.92
50	HUB 46 × C	73.70	3.50	4.37	28.57	53.56	4.13	4.28	1.52	3.72	3.13	3.37
51	Punjab Chhuhara	93.00	4.10	4.50	45.06	21.28	3.76	3.79	0.96	3.58	3.10	3.61
52	Arka Aditya	88.10	4.40	3.70	28.22	22.33	3.75	3.95	0.63	3.46	3.13	3.68
53	Kashi Chayan	61.30	3.80	3.97	38.31	12.35	4.20	3.67	0.48	3.70	3.00	4.18
	Mean	77.16	4.24	4.01	26.26	36.68	3.29	3.47	0.82	3.66	3.19	3.78
	S. Em (±)	5.61	0.44	0.23	1.02	2.50	0.12	0.08	0.04	0.11	0.11	0.11
	CD at 5%	15.92	1.25	0.66	2.89	7.11	0.35	0.25	0.13	0.32	0.31	0.32

Plant growth has a direct impact on yield, with growth parameters such as plant height and the number of branches per plant playing a crucial role. Yield is also influenced by factors such as average fruit weight, the number of fruits per cluster, and the total number of fruits per plant. Among various genotypes studied, LP 9 exhibited the highest plant height and number of branches. However, a reduction in overall crop growth was observed, possibly due to high temperatures. LP 9 also recorded the highest number of flowers per cluster, while the fewest flowers per cluster were noted in HUB 13 (3.37) and HUB 6 (3.47).

In terms of fruit weight, the genotype HUB 3 × DMT 2 showed the highest average fruit weight (46.91 g), comparable to Punjab Chhuhara (45.06 g) and HUB 46 × DMT 2 (42.39 g). The lowest fruit weight was observed in LP 9 (5.05 g). The number of fruits per cluster varied across genotypes, ranging from 0.53 to 3.53. LP 15 had the highest number of fruits per cluster (3.53), while HUB 30 had the lowest (0.53). This variation is likely due to differences in fruit set percentage and the number of fruits per cluster. These findings are consistent with previous research by Alam *et al*. (2014) [3], Jamdhade (2016) [10], Fayaz *et al*. (2007) [9], Samad *et al*. (2017) [20], Nalla and Rana (2021) [15], Kumara *et al*. (2017) [14], Khokhar *et al*. (2001) [12], Eshteshabul *et al*. (2010) [7], Turhan *et al*. (2011) [24], Abrar *et al*. (2011) [1], and Falak *et al*. (2011) [2].

It has been reported that the polar diameter of fruits ranged from 0.97 to 4.75 cm, with the maximum recorded in the genotype HUB 43 × DMT 2 (4.75 cm). The equatorial diameter varied between 1.01 and 4.77 cm, with the highest found in HUB 36 × Arka Meghali (4.77 cm), and the lowest in LP 9 (1.01 cm). Significant variations in fruit yield per plant were observed among the genotypes. The highest fruit yield per plant was recorded in HUB 46 × Arka Vikas (1.57 kg), which was significantly higher than all other genotypes. In contrast, the lowest yields were observed in HUB 3 (0.23 kg) and LP 9 (0.3 kg). This variation in yield is attributed to differences in the number of fruits and fruit clusters per plant, affecting the overall yield potential of the crop. These findings are consistent with trends reported by Seyed and Naser (2012) [21], Sureshkumara *et al*. (2017) [22], Ramya *et al*. (2016) [18], and Nalla and Rana (2021) [15]. Additionally, some genotypes, despite having a higher number of flowers per cluster, failed to set fruit due to flower drying caused by reduced pollen viability.

Pericarp thickness varied significantly among the genotypes, ranging from 2.72 mm to 4.13 mm. The genotype HUB 36 × DMT 2 had the thickest pericarp (4.13 mm), while LP 18 reported the thinnest (2.66 mm). The maximum number of locules per fruit was observed in HUB 13 × Arka Meghali (4.00), which was on par with LP 9 (3.70). In contrast, the minimum number of locules per fruit was recorded in LP 17, HUB 36 × Arka Meghali, and Kashi Chayan, each with 3.00 locules.

Total soluble solids (TSS) content also showed significant variation across the genotypes, with values ranging from 3.31 to 4.32 °Brix. The highest TSS was recorded in HUB 36 (4.32 °Brix), while the lowest was observed in HUB 13 × C (3.31 °Brix), followed by HUB 30 × Arka Vikas (3.34 °Brix). Variations in TSS among genotypes can be attributed to temperature fluctuations, while the number of locules is primarily determined by the genetic characteristics of each genotype. These findings align with trends reported by Ravinder and Cheema (2005) [19], Sureshkumara *et al*. (2017) [22], Dhillon *et al*. (2019) [6], Kumar and Bahadur (2021) [13], and Kayak *et al*. (2022) [11] in their studies on quality parameters in different tomato cultivars.

Conclusion

Among the genotypes evaluated for yield and yield-related traits, LP 9 stood out with the maximum number of branches per plant and the highest plant height. LP 8 and LP 12 were the earliest to flower, while LP 15 recorded the highest number of flowers per cluster, fruits per cluster, and fruits per plant. The genotype HUB 3 × DMT 2 had the highest average fruit weight, HUB 43 × DMT 2 had the largest polar diameter, and HUB 36 × Arka Meghali reported the greatest equatorial diameter. The highest yield was observed in HUB 46 × Arka Vikas and HUB 43 × DMT 2. Additionally, HUB 36 × DMT 2 exhibited the thickest pericarp, while HUB 36 recorded the highest total soluble solids (TSS). The maximum number of locules per fruit was found in HUB 13 × Arka Meghali, making these genotypes top performers in terms of yield.

Further investigations on the suitability of these genotypes for different seasons should be conducted. Agronomic practices can be optimized for the best-performing genotypes, and promising varieties can be screened for resistance to biotic and abiotic stresses.

To meet the demands of consumers and growers, it is crucial to evaluate tomato genotypes for various traits including growth, yield, and quality. This study aimed to assess different tomato genotypes for these attributes to identify promising cultivars for cultivation. Field experiments were conducted over the growing seasons, and data on growth parameters, yield components, and quality attributes were recorded. The results provide insights into the performance of different tomato genotypes, aiding breeders and growers in selecting varieties that meet specific market preferences and production requirements. The identification of promising cultivars with superior performance in key agronomic traits is crucial for sustainable tomato production and meeting consumer preferences. Further research is warranted to elucidate the underlying genetic mechanisms controlling these traits and to develop improved varieties with enhanced yield potential, nutritional quality, and resilience to biotic and abiotic stresses. Such efforts are essential for ensuring food security and promoting the sustainable production of high-quality tomatoes worldwide.

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