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COMPREHENSIVE ANALYSIS OF YIELD, QUALITY AND FUSARIUM WILT RESISTANCE IN TOMATO GENOTYPES

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ABSTRACT

This study aimed to evaluate the growth, yield, quality and Fusarium wilt resistance of thirty tomato germplasm lines under open field conditions. The experiment was conducted at the vegetable experimental farm of the College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem, during the *Rabi* season of 2022- 2023. A comprehensive analysis of variance revealed significant differences among the genotypes for all traits examined. Notably, the genotype EC-620403 exhibited early flowering, achieving 50% flowering in just 29.54 days. EC-617090 demonstrated superior vegetative growth with a plant height of 180.22 cm. For fruit yield, EC-631396 was the leading genotype, yielding 1.44 kg per plant, excluding check varieties. The highest total soluble solids (TSS) content was recorded in EC-611885 at 5.65 °Brix and EC-806571 had the highest lycopene content, measured at 7.23 mg/ 100g. Additionally, EC-631396 and a local collection exhibited the lowest severity of Fusarium wilt under natural conditions. The findings suggest significant genetic variability among the tomato genotypes, which is crucial for selecting superior parents for breeding programs aimed at improving tomato traits. This research provides a foundational understanding for developing new tomato cultivars with enhanced growth, yield, quality and disease resistance.

Key words : Germplasm, Fusarium wilt Resistance, Yield performance, Genotypic variability, Quality traits and Open field conditions.

Introduction

India is a leading global producer of vegetables, ranking second worldwide, and plays a crucial role in ensuring nutritional security by providing a cost-effective source of essential nutrients such as proteins, vitamins, minerals, and carbohydrates. Among the vegetable crops, tomato (*Solanum lycopersicum* L.) holds significant importance, ranking as the world's third-largest vegetable crop after potato and onion. India stands second in tomato cultivation area and production, following China. Tomatoes, a key member of the Solanaceae family with a chromosome number of 2n=2x=24, are believed to have originated in the Peru-Ecuador region of the Andes in South America from their wild ancestor, *Solanum lycopersicum* var. *cerasiforme*.

The year-round availability of tomatoes makes them susceptible to various pests and diseases, which significantly impact yield. Common diseases affecting tomatoes include fungal and bacterial wilts, blights, bacterial canker, tomato yellow leaf curl virus, tomato spotted wilt virus and anthracnose. Among these, Fusarium wilt, caused by different Fusarium species, is particularly devastating, leading to substantial crop losses both in green houses and open fields (Amini and Sidovich, 2010; Abdel-Monaim *et al*., 2011), with potential yield reductions ranging from 10% to 80% (Bharat and Sharma,

2014). The systematic evaluation and study of tomato germplasm are critical for the agronomic and genetic enhancement of the crop. Such evaluations provide essential insights into the genetic diversity and breeding potential of available germplasm, which are crucial for breeding programs aimed at developing improved tomato genotypes (Singh *et al.*, 2002). The breeding process involves generating diverse germplasm, incorporating various sources of resistance, and selecting superior genotypes for hybridization. This preliminary study aims to assess the growth, yield and quality traits of different tomato genotypes laying the ground work for future breeding efforts to enhance tomato production and disease resistance.

Materials and Methods

The experiment was conducted at the College Farm of the College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem, West Godavari District, during the *Rabi* season of 2022-2023. The trial was designed in a Randomized Block Design (RBD) with 30 tomato genotypes and two replications. The experimental material included 27 germplasm lines and 3 released varieties (Arka Vikas, Arka Meghali and PKM-1) obtained from NBPGR, Hyderabad, IIHR, Bengaluru and TNAU, Periyakulam (Table 1). The experimental site was well-prepared and managed using standard cultural practices such as training, pruning, weeding, irrigation, fertilizer application and plant protection measures to ensure the healthy growth of the crop. Seedlings were initially raised in portrays and then transplanted in to the open field at approximately four weeks old, with a spacing of 60 cm between rows and 45cm between plants, covering an area of 500 square meters.

Observations were recorded on five randomly tagged plants per plot for various growth and yield parameters, including plant height (cm), days to 50% flowering, number of flowers per cluster, number of fruits per cluster, percentage fruit set, days to first fruit harvest, fruit length (cm), fruit diameter (cm), average fruit weight (g), pericarp thickness (mm), number of locules per fruit, number of fruits per plant, fruit yield per plant (kg), and estimated yield (t/ ha). Quality traits were assessed by measuring ascorbic acid content (mg/ 100g) using A.O.A.C. (1975) procedures, lycopene content (mg/ 100g) following Ranganna (1979) and total soluble solids (TSS, °Brix) using a digital refractometer. Fusarium wilt incidence was calculated as the percentage of infected plants out of the total observed, multiplied by 100. The collected data were subjected to statistical analysis using the analysis of variance (ANOVA) method as described by Panse and Sukhatme (1957). The significance of treatment effects was determined using the F-test at a 5% significance level. If the calculated F-value exceeded the table value, the effect was considered significant.

Table 1 : List of tomato genotypes used in the study.

S. no.	Genotypes	Source
1	EC-164656	NBPGR, Hyderabad
2	EC-620414	NBPGR, Hyderabad
3	EC-620408	NBPGR, Hyderabad
4	EC-620407	NBPGR, Hyderabad
5	EC-620360	NBPGR, Hyderabad
6	EC-617083	NBPGR, Hyderabad
7	EC-617090	NBPGR, Hyderabad
8	EC-620775	NBPGR, Hyderabad
9	EC-631396	NBPGR, Hyderabad
10	EC-631406	NBPGR, Hyderabad
11	EC-631410	NBPGR, Hyderabad
12	EC-631415	NBPGR, Hyderabad
13	EC-635520	NBPGR, Hyderabad
14	EC-636482	NBPGR, Hyderabad
15	EC-654286	NBPGR, Hyderabad
16	Localcollection	-
17	EC-806571	NBPGR, Hyderabad
18	EC-806566	NBPGR, Hyderabad
19	EC-605711	NBPGR, Hyderabad
20	EC-241148	NBPGR, Hyderabad
21	EC-164656	NBPGR,Hyderabad
22	EC-806572	NBPGR, Hyderabad
23	EC-611885	NBPGR, Hyderabad
24	EC-161245	NBPGR, Hyderabad
25	EC-620401	NBPGR, Hyderabad
26	EC-620403	NBPGR, Hyderabad
27	EC-620410	NBPGR, Hyderabad
28	ArkaVikas	IIHR, Bengaluru
29	Arka Meghali	IIHR, Bengaluru
30	PKM-1	TNAU, Periyakulam

Results and Discussion

The analysis of variance (ANOVA) demonstrated that there were highly significant differences among the tomato genotypes for all evaluated traits (Table 2), indicating substantial genetic variability within the germplasm. This variability is crucial for selecting superior genotypes for breeding programs aimed at enhancing tomato yield, quality, and disease resistance. The data on mean performance was presented in Tables 3 and 4.

Table 2 : Analysis of variance for yield, yield attributes, quality parameters and fusarium wilt incidence in various tomato genotypes.

S. no.	Character	Mean sum of squares		
		Replications (df:1)	Treatments (df:29)	Error (df:29)
1.	Plant height	12.11	1744.19**	11.57
2.	Days to 50% flowering	0.05	42.26**	0.79
3.	Number of flowers per cluster	0.00	4.08**	0.03
4.	Number of fruits per cluster	0.03	5.19**	0.02
5.	Fruit set (%)	1.88	297.14**	3.11
6.	Days to first fruit harvest	8.45	92.56**	4.52
7.	Fruit length (cm)	0.03	3.75**	0.01
8.	Fruit diameter (cm)	0.00	2.02**	0.01
9.	Average fruit weight (g)	0.85	972.80**	3.42
10.	Pericarp thickness (mm)	0.00	7.53**	0.03
11.	Number of locules per fruit	0.00	1.61**	0.01
12.	Number of fruits per plant	0.65	1856.90**	0.96
13.	Fruit yield per plant (kg)	0.00	0.19**	0.00
14.	Estimated yield (t/ha)	3.81	145.96**	1.17
15.	TSS (^{0}Brix)	0.01	1.82**	0.01
16.	Lycopene content (mg/100g)	0.00	2.24**	0.02
17.	Vitamin-C content (mg/100g)	2.75	32.61**	0.26
18.	Percent incidence (Fusarium wilt)	11.60	1559.53**	2.74

**Significant at 1% level.

Growth and flowering traits

Plant height among the genotypes varied significantly, ranging from 76.01 cm in EC- 241148 to 180.22 cm in EC-617090, with a mean of 129.97 cm. EC-617090 recorded the maximum plant height, indicating its potential for higher vegetative growth, which can be advantageous for fruit development. Early flowering, indicated by the number of days to 50% flowering, ranged from 29.54 days in EC-620403 to 45.60 days in EC-617090. Genotypes like EC-620403, which flowered earlier, are valuable for breeding early- maturing varieties.

Yield and Yield contributing traits

The number of flowers per cluster ranged from 3.39 to 9.66, with the local collection showing the highest number of flowers per cluster, suggesting its potential for higher fruit production. The number of fruits per cluster varied from 1.60 to 7.77, with the local collection again recording the highest value, demonstrating its superior reproductive potential.

Fruit set percentages were notably diverse, with values ranging from 40.25% in EC- 806572 to88.22% in EC-631396. High fruit set percentages are indicative of efficient pollination and fruit formation, crucial for maximizing yield. The days to first fruit harvest varied between 60.86 days in EC-806566 and 86.66 days in Arka Vikas, highlighting genotypes that can be targeted for early harvest.

Fruit Quality traits

Fruit length and diameter also varied significantly, with EC-654286 recording the highest fruit length (7.45 cm) and EC-605711 the highest fruit diameter (5.92cm). These traits are essential for market acceptance and consumer preference. Average fruit weight ranged from 9.65 g in EC-611885 to 82.06 g in EC-620407, with heavier fruits often associated with better yield potential.

Pericarp thickness and the number of locules per fruit showed considerable variation, which impacts the fruit's storage life and processing quality. The number of fruits per plant ranged from 8.16 in EC-806572 to 137.10 in EC-611885, with higher numbers indicating better yield potential.

Yield and Biochemical characteristics

The fruit yield per plant varied from 0.55 kg to 1.64 kg, with Arka Vikas achieving the highest yield, indicating its superiority in yield attributes. Similarly, total soluble solids (TSS), a key quality indicator, ranged from 2.13 °Brix in EC-631415 to 5.65 °Brix in EC- 611885, with higher TSS values suggesting better taste and shelf life. Lycopene content, important for nutritional quality, varied from 3.72 mg/100g in Arka Vikas to 7.23 mg/ 100g in EC-806571, with high lycopene levels being beneficial for health due to their antioxidant properties. Ascorbic acid content varied significantly, highlighting the potential for selecting genotypes with higher nutritional quality.

Fusarium wilt resistance

Disease incidence varied widely among genotypes, with EC-631396 and the local collection showing no symptoms of Fusarium wilt, indicating strong resistance. In contrast, EC-241148 showed the highest disease incidence at 90.65%, demonstrating susceptibility. Effective resistance in genotypes like EC-631396 is crucial for breeding disease-resistant varieties to minimize yield losses.

Fig. 1 : Distribution of Fruit Set (%) among genotypes.

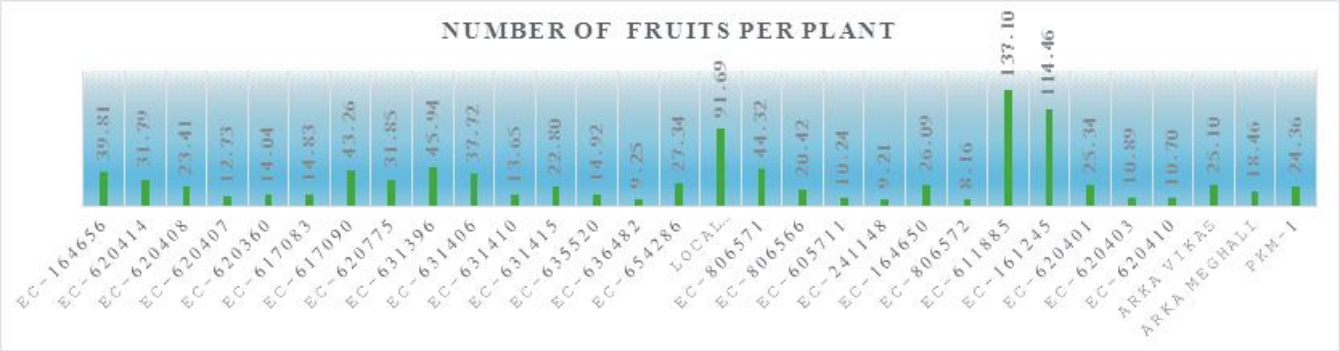

Fig. 2 : Distribution of number of fruits per Plant among genotypes.

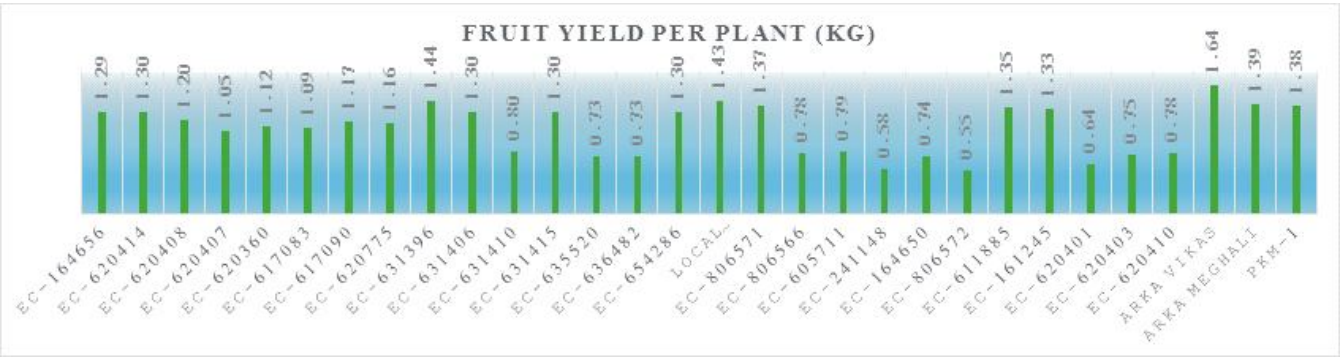

Fig. 3 : Distribution of Fruit yield per plant (kg) among genotypes.

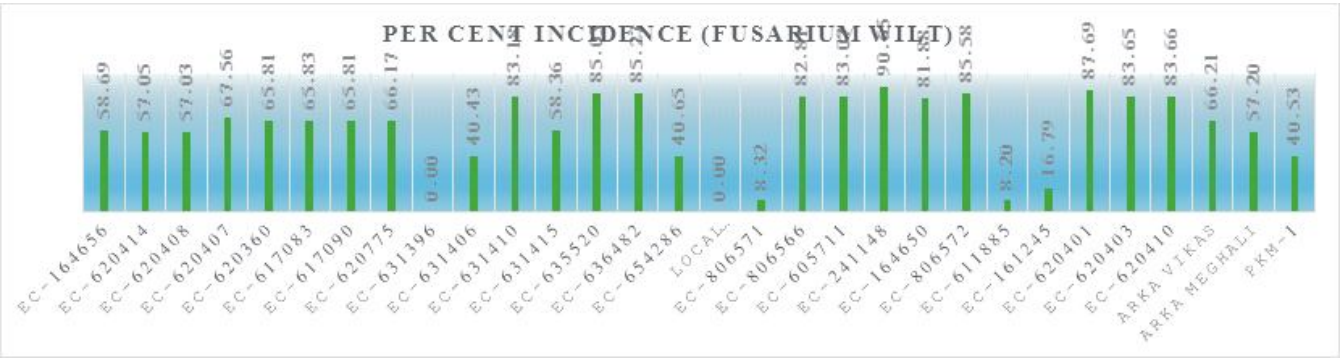

Fig. 4 : Distribution of per cent incidence (*Fusarium* wilt) among genotypes.

Overall, the observed genetic variability in growth, yield, quality traits and disease resistance among the tomato genotypes provides valuable information for breeders. Selecting and cross breeding the superior genotypes identified in this study can lead to the development of improved tomato varieties with enhanced yield, quality and resistance to Fusarium wilt.

Table 3 : Mean performance of yield attributes in various tomato genotypes.

Genotypes	Plant height (cm)	Days to 50% flowering	Number of flowers/ cluster	Number of fruits/cluster	Fruit set (%)	Days to first harvest	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)
EC-164656	129.43	39.50	6.55	4.38	66.87	75.81	3.74	4.22	32.40
EC-620414	128.29	39.17	6.42	4.20	65.54	75.39	6.30	4.88	40.99
EC-620408	121.38	37.69	6.11	3.95	64.75	74.60	5.97	3.23	51.08
EC-620407	150.16	42.53	5.94	3.64	61.28	77.55	6.48	3.45	82.06
EC-620360	116.38	36.34	6.11	3.85	62.91	74.99	5.46	4.45	80.31
EC-617083	152.72	42.11	5.91	3.63	61.44	82.75	3.98	5.56	73.60
EC-617090	180.22	45.60	6.90	5.38	77.92	83.70	3.99	4.15	26.69
EC-620775	126.84	37.06	6.28	4.76	75.74	81.74	4.47	3.72	36.25
EC-631396	154.39	42.12	7.80	6.88	88.22	80.68	3.97	4.34	32.16
EC-631406	142.27	39.00	7.46	5.30	70.98	75.60	3.79	3.34	34.04
EC-631410	117.68	36.72	5.77	3.40	58.86	72.25	3.02	4.60	58.57
EC-631415	161.09	42.96	6.98	4.65	66.65	82.89	4.35	3.97	56.68
EC-635520	172.63	42.90	5.93	3.20	53.98	84.55	3.12	4.43	49.66
EC-636482	129.05	32.81	5.70	3.04	53.37	67.05	6.04	5.15	78.96
EC-654286	168.18	43.44	8.71	6.59	75.66	76.23	7.45	4.29	46.73
Localcollection	141.25	40.57	9.66	7.77	80.49	71.17	3.58	2.99	15.96
EC-806571	166.18	43.24	7.89	6.45	81.65	72.05	4.83	5.61	30.60
EC-806566	97.68	33.22	5.38	3.16	58.66	60.86	4.29	3.27	38.39
EC-605711	102.29	35.70	5.85	3.43	58.58	66.98	5.57	5.91	78.04

Genotypes	Plant height (cm)	Days to 50% flowering	Number of flowers/ cluster	Number of fruits/cluster	Fruit set (%)	Days to first harvest	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)
EC-241148	76.01	31.58	3.39	1.60	47.29	66.79	5.23	4.57	63.64
EC-164650	99.01	32.11	5.77	3.10	53.70	66.45	2.98	3.73	27.62
EC-806572	145.23	42.79	4.02	1.62	40.25	70.94	6.13	5.26	67.03
EC-611885	177.57	44.27	8.77	7.24	82.48	69.45	1.91	1.68	9.65
EC-161245	138.55	40.06	7.23	6.22	86.08	67.58	2.51	2.31	11.66
EC-620401	136.89	39.86	4.23	2.15	50.93	70.44	2.47	3.10	25.29
EC-620403	96.62	29.54	5.01	2.85	56.87	61.54	6.36	5.29	69.09
EC-620410	98.34	31.26	5.28	3.02	57.29	66.35	5.32	5.20	72.23

Table 3 continued...

Table 3 continued...

Arka Vikas	90.77	31.18	4.96	3.79	76.46	86.66	3.97	4.97	65.77
Arka Meghali	94.13	31.39	5.25	3.91	74.44	74.42	4.40	4.96	75.47
PKM-1	88.15	39.04	4.75	3.56	74.98	74.28	4.10	4.38	56.66
Grand Mean	129.97	38.39	6.20	4.22	66.14	73.72	4.53	4.23	49.57
Range lowest	76.01	29.54	3.39	1.60	40.25	60.86	1.91	1.68	9..65
Range highest	180.22	45.60	9.66	7.77	88.22	86.66	7.45	5.92	82.06
C.V.	6.62	2.32	2.60	3.53	2.67	2.89	2.42	2.74	3.73
S.E.	2.41	0.63	0.11	0.11	1.25	1.50	0.08	0.08	1.31
C.D.5%	6.96	1.82	0.33	0.30	3.60	4.35	0.22	0.24	3.78

Table 4 : Mean performance of yield attributes, quality traits and percent incidence of fusarium wilt in various tomato genotypes.

Genotypes	**Pericarp thickness (mm)**	**Number of locules/fruit**	**Number of fruits/ plant**	**Fruit yield per plant (kg)**	**Estimated yield (t/ha)**	**TSS (^{0}Brix)**	**Lycopene (mg/100g)**	**Vitamin-C (mg/100g)**	**Per cent incidence (Fusarium wilt)**
EC-164656	4.20	3.06	39.81	1.29	35.97	4.49	6.07	21.42	58.69
EC-620414	4.59	2.29	31.79	1.30	36.08	5.54	4.16	24.03	57.05
EC-620408	4.91	4.32	23.41	1.20	33.26	5.04	4.49	25.49	57.03
EC-620407	5.00	4.12	12.73	1.05	29.14	2.54	5.59	26.08	67.56
EC-620360	5.29	4.56	14.04	1.12	31.19	4.39	6.59	26.29	65.81
EC-617083	4.91	3.12	14.83	1.09	30.15	5.13	6.77	13.03	65.83
EC-617090	3.81	3.65	43.26	1.17	32.53	3.20	4.15	18.93	65.81
EC-620775	2.89	4.14	31.85	1.16	32.27	2.50	4.36	24.81	66.17
EC-631396	1.40	3.15	45.94	1.44	40.06	4.47	4.52	24.85	0.00
EC-631406	2.13	2.68	37.72	1.30	36.12	4.53	4.63	25.55	40.43
EC-631410	5.46	2.32	13.65	0.80	22.16	5.20	4.97	23.94	83.18
EC-631415	4.27	2.14	22.80	1.30	36.03	2.13	4.80	25.38	58.36
EC-635520	5.94	2.98	14.92	0.73	20.17	2.57	4.85	24.04	85.03
EC-636482	6.74	2.33	9.25	0.73	20.31	2.99	6.19	25.63	85.27
EC-654286	2.04	2.01	27.34	1.30	36.05	4.29	5.84	26.43	40.65
Local collection	1.56	2.14	91.69	1.43	39.75	4.14	4.09	17.20	0.00
EC-806571	1.69	3.42	44.32	1.37	38.13	4.35	7.22	18.08	8.32
EC-806566	6.43	2.33	20.42	0.78	21.76	4.83	4.64	26.26	82.81
EC-605711	6.19	4.72	10.24	0.79	22.01	3.89	4.48	20.06	83.07

Table 4 continued...

Table 4 continued...

Genotypes	Pericarp thickness (mm)	Number of locules/fruit	Number of fruits/ plant	Fruit yield per plant (kg)	Estimated yield (t/ha)	TSS (^{0}Brix)	Lycopene (mg/100g)	Vitamin-C (mg/100g)	Per cent incidence (Fusarium wilt)
EC-241148	7.22	3.32	9.21	0.58	16.19	4.47	4.60	15.35	90.65
EC-164650	6.45	2.30	26.09	0.74	20.50	4.70	3.78	17.29	81.88
EC-806572	7.41	2.29	8.16	0.55	15.18	4.22	3.87	22.18	85.58
EC-611885	1.66	2.16	137.10	1.35	37.49	5.65	5.32	17.69	8.20
EC-161245	1.61	2.33	114.46	1.33	36.95	5.20	3.87	19.01	16.79
EC-620401	6.97	2.00	25.34	0.64	17.74	5.15	6.83	18.96	87.69
EC-620403	6.45	3.10	10.89	0.75	20.95	4.33	5.28	20.95	83.65
EC-620410	6.31	2.96	10.70	0.78	21.54	4.47	6.70	22.72	83.66
ArkaVikas	5.12	4.24	25.10	1.64	45.58	4.85	3.72	28.58	66.21
Arka Meghali	6.24	4.21	18.46	1.39	38.60	5.06	3.90	27.53	57.20
PKM-1	4.17	4.27	24.36	1.38	38.33	5.12	3.97	26.24	40.53
Grand Mean	4.63	3.10	31.89	1.08	30.01	4.31	5.01	22.47	59.11
Range lowest	1.40	2.00	8.16	0.55	15.18	2.13	3.72	13.03	0.00
Range highest	7.41	4.72	137.10	1.64	45.58	5.65	7.23	28.58	90.66
C.V.	3.52	2.63	5.07	5.63	5.61	2.81	2.65	2.26	2.80
S.E.	0.12	0.06	0.69	0.03	0.77	0.09	0.09	0.36	1.17
C.D.5%	0.33	0.17	2.00	0.08	2.22	0.25	0.27	1.04	3.39

The results obtained are in agreement with the findings of Pradeep Kumar *et al*. (2001), Kaur *et al*. (2002), George *et al*. (2004), Joshi and Kohli (2005), Jogi *et al*. (2008), Singh *et al*. (2010), Gonzalez-Cebrino *et al*. (2011), Narolia *et al*. (2012), Pembasherpa *et al*. (2014) and Venkadeswaran *et al*. (2020).

Conclusion

This study identified genotypes EC-631396, Local collection, EC-806571, EC- 611885 and EC-161245 as top performers, yielding higher fruit output with minimal Fusarium wilt incidence. These genotypes showed promising fruit set percentages, highlighting their potential for high productivity. Additionally, genotypes EC-620403, EC- 241148, EC-164650, EC-636482 and EC-806566 exhibited early flowering, making them ideal for breeding programs focused on early maturation. These findings suggest that the superior genotypes can be utilized as elite germplasm for breeding or recommended for commercial cultivation after extensive testing. Their adoption can significantly enhance tomato production, offering robust yield and disease resistance, thereby contributing to sustainable agricultural practices.

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