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STUDY OF MORPHOLOGICAL VARIABILITY ALONG WITH YIELD ATTRIBUTES IN TOMATO (*SOLANUM LYCOPERSICUM* L.) UNDER GWALIOR REGION OF INDIA

Keshav Deshmukh and Chandra Kant Sharma*

Department of Horticulture, Vegetable Science, ITM University, Gwalior - 474 001, Madhya Pradesh, India.

*Corresponding author E-mail : ck21sharma@gmail.com

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ABSTRACT

To calculate yield contributing characteristics, genetic progress, variability, and heritability in tomato genotypes, thirty genotypes were analyzed. In all attributes, the phenotypic coefficient of variation (PCV) was greater in magnitude than the genotypic coefficient of variation (GCV). In terms of the number of fruits/ plant, number of fruits/clusters, plant height, average fruit wt, days to first fruit harvest, days to 1st fruit setting, fruit yield/ plant, plant height and number of clusters/ plant, high genotypic variation was observed along with high PCV, GCV and heritability as a percentage of mean. For every attribute, including the no. of fruits/plants, average fruit wt, days until first fruit harvest, and days until first fruit setting, these estimations showed strong heritability (broad sense) values. The plant height, number of clusters/plant and fruit output/ plant were found to have the highest estimated genetic advance.

Key words : Tomato, Variability, Heritability, Genetic advance and Yield.

Introduction

Tomato known as *Solanum lycopersicum* L. is a very valuable vegetable crop that is grown all over the globe due to its versatility and high production potential, and versatility used in a variety of processed food sectors as well as for fresh food purpose. Peru is the original home of the tomato plant. It is also called the "love apple" in England, although it is also called the "poor man's orange" in India. Mexico is thought to be the birthplace of tomatoes that are grown, while wild tomatoes are believed to have originated in the Peru-Ecuador region (Peralta *et al*., 2008).

Lycopene, which gives tomatoes their red color, is increasingly referred to as the "world's most powerful natural antioxidant". With a yield potential of up to 42.1 t/ ha, tomatoes (2n=2x=24) are an important vegetable crop in the globe (Yamaguchi, 1983). It belongs to the Solanaceous family, which also includes potatoes, pepper, and aubergine, three other economically significant crops. With its new designation, the genus *Lycopersicum* reintegrated into the genus Solanum according to the most recent revision of the evolutionary classification of the Solanaceous family (Peralta *et al*., 2008). Consequently, the genus *Solanum* is currently included in the clade *Lycopersicum*. The cultivated tomato *Solanum lycopersicum* L. and its twelve closest wild cousins belong to the clade *Lycopersicum* (Peralta and Spooner, 2005; Peralta *et al*., 2008).

The tomato is one of the most commonly produced vegetables in the world. It is ranked seventh on the world's significant crop species list and second among vegetable crops. In terms of production, it ranks second only to potatoes and onions in India. Growing commercially in 159 nations, it has spread to nearly every area of the world since its introduction in the 16th century (Saker *et al*., 2011). Farmers have come to love this crop because of its short growing season, high potential yield, high profitability and economic feasibility due to its high levels of preventive and nutritional qualities (Chauhan *et al*., 2014).

Feasibility due to its high levels of preventive and nutritional qualities (Chauhan *et al*., 2014). In the nation, there are roughly 0.841 million hectares dedicated to tomato growing. With 24.36 metric tons per hectare as the average national productivity, the total production is 20.34 million metric tonnes (Anonymous, 2022). China is the country with the largest area (11280 thousand ha) and output (204613 MT), but India is much less productive than several other major producing nations, with only 25.6 tons/ha. In India, the state Andhra Pradesh is the top tomato-producing state. In Madhya Pradesh (M.P.) tomatoes are a prominent vegetable crop that is grown extensively. With 47.45 thousand hectares under cultivation, 1121 metric tonnes of tomatoes are produced overall in M.P., the average tomato productivity per hectare is 24.90 tonnes (Anonymous, 2022).

The tomato is an excellent source of minerals (Ca, P, and Fe), vitamins (A and C) and a potent antioxidant that guards against heart disease and cancer (Dhaliwal *et al*., 2003; Anonymous, 2011). Because of its unique nutritional value and antioxidant qualities resulting from the presence of flavonoids and lycopene, it is regarded as a "protective food" (Sepat *et al*., 2013). Tomatoes are regarded as an important crop for both commercial and dietary use and as a preventive supplement. Additionally, according to Bugianesi *et al*. (2004), it is a good source of polyphenolic components like hydroxyl cinnamon acids and flavonoids. It has a wealth of organic acids, vitamins, and minerals that provide the body with significant antioxidant properties (Tomlekova *et al*., 2007; Glogovac *et al*., 2010), which help prevent and treat chronic illnesses including both heart disease and cancer. (Canene- Adams *et al*., 2005; Omoni and Aluko, 2005; Kun *et al*., 2006). Lycopene and ascorbic acid, two powerful antioxidants with chemo-protective qualities, are abundant in tomatoes. Tomatoes fit the category of functional food because of these characteristics (Akhtar and Hazra, 2013). Tomatoes are considered healthful because they contain a variety of antioxidants, including flavonoids, ascorbic acid (vitamin C), phenolic compounds, and carotenoids (including lycopene and beta-carotene). These antioxidants are essential for fostering health and wellbeing. (Frusciante, 2007). Thus, an investigation of the genetic diversity, inheritance and gain among several tomato genotypes for various horticultural parameters was attempted.

Materials and Methods

Thirty tomato genotypes were grownin the during the *kharif* season 2023-24. At the CRC-3 Research Farm, the field experiment was carried out. I.T.M. University, Gwalior, M.P. The farm, on sandy loam soil was fertile, well-drained and levelled. The pH of the soil was 7.2. School of Agriculture, ITM University, Gwalior, Madhya Pradesh, prepared plant materials in the CRC-3. The fruit quality evaluations were carried out in the postgraduate lab of the ITM University's Gwalior, Madhya Pradesh. Its location is at an elevation of 220.50 meters higher than sea level in the Gird belt (MLS) in the Gird area of India, at 26" 21 N latitude and 78° 20' E longitude. Southwest of Gwalior's main city centre is where it is located. This region has a distinct sea and somewhat semi-arid climate that ranges from tropical to subtropical. The months of March through The hottest month is June, utilizing a maximum average temperature of 35°C to 45°C (95°F to 113°F). These three replications of replicated experiments were used to plant genotypes. From the seeds collected from the nursery during the autumn winter season of 2023–2024 in the field (CRC–3). To enable drainage and irrigation, thirty-day-old, dry seedlings were moved to an elevated bed with 90 x 40 cm spacing. Table

Table 1 : List of tomato genotypes used in field trail.

S. no.	Genotypes	Source
1	Kashi Hemant	IIVR, Varanasi
2	Deshi Red	Local collection
3	Deep Deshi	Local collection
4	Pusa Uphar	IIVR, Varanasi
5	ZS-21	Local collection
6	Pusa Rohini	IIVR, Varanasi
7	CO-3	IIVR, Varanasi
8	Kashi Adarsh	IIVR, Varanasi
9	Pusa Seetal	IIVR, Varanasi
10	EC-620424	IIVR, Varanasi
11	EC-620444	IIVR, Varanasi
12	NF-54	Local collection
13	Kashi Anupam	IIVR, Varanasi
14	Cherry Tomato	Local collection
15	Kashi Vishesh	IIVR, Varanasi
16	Kashi Amrit	IIVR, Varanasi
17	Kashi Ruby	IIVR, Varanasi
18	Hisar Arun	IIVR, Varanasi
19	Arka Vikas	IIVR, Varanasi
20	Panjab Chhuhara	IIVR, Varanasi
21	Swarna Naveen	IIVR, Varanasi
22	Panjab Keshari	IIVR, Varanasi
23	Roma	IIVR, Varanasi
24	Azad T-5	IIVR, Varanasi
25	Pant-T3	IIVR, Varanasi
26	Swarna Lalima	IIVR, Varanasi
27	Flora Date	IIVR, Varanasi
28	Kashi Sharad	IIVR, Varanasi
29	BN-10-2	IIVR, Varanasi
30	Angor Lata	IIVR, Varanasi

1 provides specifics on the plant materials that were utilized. Seventeen yield and attributing traits and quality parameters were recorded. The yield-attributing traits included plant ht (cm), no. of primary branches/plant as well as days to first flowering, days to 50% flowering as well as days to first fruit harvest, average fruit weight (g), fruit polar diameter (mm), fruit equatorial diameter (mm), fruit shape index, number of locules, pericarp thickness (mm), no. of flowers per cluster, no. of flower cluster per plant, no. of fruits per cluster, no. of fruits/ plant, fruit yield/plant (g), Total yield (q/ha). The genotypic coefficient of variance (GCV) and phenotypic coefficient of variance (PCV) were estimated according to Comstock and Robinson (1952). Conversely, the heritability estimate was calculated in accordance with Lush (1940) and the genetic progress was anticipated using the approach recommended by Johnson *et al*. (1955) and Lush (1949).

Results and Discussion

The recorded data on all quantitative characters were tested by running an analysis of differences if there was significant variation between the genotypes. Analysis of variance has been presented in Table-2 show that for each character, the genotypes' mean square was quite significant. Suggesting significant variability among every feature being examined and indicates the existence of ample scope for selection. Genetic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, and genetic progress are the estimations of genetic variability for various traits. And genetic advance as a percent of mean, which have been depicted in Table3. The coefficient of genotypic and phenotypic variability is a useful tool for determining the degree of variability in a given characteristic. Additionally, they function as a statistic for contrasting the level of variability across various quantitative parameters. For every trait, the phenotypic coefficient of variation (PCV) was greater than the genotypic coefficient of variation (GCV) in terms of magnitude (Table 3). Ahirwar *et al*. (2013), Kumar *et al*. (2016), and Pandey *et al*. (2018) reported highervalues of PCV compared to GCV. The greater PCV values relative to GCV values suggested that all of the qualities under investigation were influenced by the environment, as Dar and Sharma (2011) have previously reported. Siva Subramanyan and Madhava Menon (1973) categorized PCV and GCV as high when they exceeded 20%, moderate when it was between 10% and 20%, and low when it was less than 10%. In terms of the number of fruits/plant, number of fruits/cluster, plant height, average fruit wt, days to first fruit harvest, days to first fruit setting, fruit yield/plant, plant ht and no. of clusters/plant, high genotypic variation was observed along with high PCV, GCV and heritability as a percentage of mean. For every attribute, including the number of fruits/plants, average fruit weight, days until the first fruit harvest and days until the first fruit setting, these estimations showed strong

Table 2 : Analysis of variance (mean squares) for 19 characters in 16 tomato genotypes.

Source of Variation	Replication	Treatment	Error	Total
DF	**2**	**29**	**58**	**89**
Days to first flowering	2.02	1317.82**	220.64	1540.48
Days to first fruit setting	42.46	1870.10**	317.53	2230.10
Days to 50% flowering	1.48	2398.32**	189.84	2589.65
Days to first fruit harvest	86.29	16598.28**	444.59	17129.169
Average fruit weight (g)	7.52	16341.72**	229.63	16578.88
Fruit equatorial diameter (mm)	39.59	5777.48 **	544.23	6361.32
Polar diameter (mm)	190.91	5287.54**	1212.45	6690.91
Locule number	0.08	67.69**	8.04	75.82
Pericarp thickness (mm)	0.21	67.68**	8.84	76.74
Number of fruits/clusters	3.98	668.81**	42.58	715.38
Number of cluster / plants	31.45	32398.98 **	1763.74	34194.18
Number of fruits /plants	4.28	13731.82**	92.37	13828.48
Number of primary branches/plants	0.27	173.71**	44.86	218.85
Plant height (cm)	26.97	52067.82**	2744.80	54839.61
Fruit weight per plant	32142.00	4948.73**	4691.04	5450.78
Fruit yield /plot	3.84	456.91**	49.38	510.15
Total yield /hectare	10.66	1847.92**	184.33	2042.92

* and ** depict significance at $p \leq 0.05$ and $p \leq 0.01$, respectively.

Table 3 : Estimates of phenotypic, genotypic coefficients of variation, heritability in broad sense (h^2_{bs}) and genetic advance in per cent of mean $(\overline{GA})$ for seventeen characters in tomato genotypes.

Characters	Heritability	Genotypic coefficient of Variance	Phenotypic coefficient of Variance	Genetic Advance	GA as % of Mean
Days to first flowering	79.00	12.62	14.25	6.80	23.04
Days to first fruit setting	78.00	11.74	13.28	8.08	21.39
Days to 50% flowering	89.00	14.03	14.87	10.00	27.26
Days to first fruit harvest	96.00	14.25	14.53	27.71	28.77
Average fruit weight (g)	98.00	22.69	22.93	27.83	46.24
Fruit equatorial diameter (mm)	87.00	16.46	17.64	15.29	31.65
Polar diameter (mm)	72.00	15.62	18.41	12.82	27.30
Locule number	84.00	25.65	27.98	1.62	48.41
Pericarp thickness (mm)	83.00	19.54	21.50	1.60	36.57
Number of fruits/clusters	91.00	47.27	49.54	5.36	92.88
Number of clusters/plants	92.00	28.52	29.70	37.68	56.46
Number of fruits/plants	99.00	55.23	55.50	25.71	113.20
No of primary branches/plant	69.00	18.83	22.63	2.26	32.25
Plant height (cm)	93.00	29.25	30.41	47.83	57.95
Fruit yield / plant (Kg)	87.00	18.17	19.48	447.24	34.91
Fruit yield (Kg/plot)	85.00	17.54	18.98	4.24	33.39
Total yield (q/ha)	86.00	17.28	18.59	8.60	33.08

heritability (broad sense) values. The highest estimate of genetic advance was recorded in fruit yield/plant, plant ht and number of clusters/plant.

Genetic progress and heritability were considered crucial selection factors. Genetic variation combined with a heritability estimate would provide a more accurate understanding of the selection's effectiveness. When the degree of variation for a certain characteristic across genotypes is indicated by genotypic coefficients of variance, estimation of heritability becomes significant. The heritability of a character is the proportion of its variability that is passed on to offspring. High genetic progress was noted as a percentage of mean for the number of fruits / plant, number of fruits / cluster and plant height. High heritability was noted for the number of fruits/plants, average fruit weight and days to first fruit harvest. The variation is largely caused by the interaction of genes. It suggests that selection predicated on these characteristics is quite desirable. All of the traits under investigation have strong heritabilities, indicating that additive gene action predominates for the traits; Kumar *et al*. (2008), Ara *et al.* (2009), Agarwal *et al*. (2014), Bhandari *et al*. (2017) and Maurya *et al.* (2023) had previously published findings of a similar nature.

Johnson (1955) asserts that more precise estimates of genetic gain under selection result from combining the estimate of genetic advance with heredity. Genetic advance was categorised as follows by Johnson *et al*. (1955): low (less than 10%), moderate (10–20%) and high (more than 20%) as a percentage of the mean. Burton and DeVane (1953) proposed that genetic coefficients of variability, may be utilized in conjunction with heritability estimations to forecast the level of improvement anticipated by selection. The heritability was high for all traits *viz*, number of fruits/plant (99.00%), average fruit weight (98.00%), days to first fruit harvest (96.00%), and days to first fruit setting (78.00%), polar diameter (72.00%) and number of primary branches per plant (69.00%) revealed moderate heritability (Table 3). For every variable studied, the heritability was high, indicating that additive gene activity predominates in the attributes. Kumar *et al*. (2008), Ara *et al*. (2009), Agarwal *et al*. (2014) and Maurya *et al*. (2022) had previously published findings of a similar nature. When heritability and the estimated genetic advancement are combined, it leads to more accurate predictions under selection, of genetic gain reported by Johnson *et al*. (1955). The highest estimate of genetic advance was recorded in fruit yield / plant (447.24%), plant height (47.83%) and no. of clusters per plant (37.68%) whereas number of primary branches per plant (2.26%), locule number (1.62%) and pericarp thickness (1.60%) showed lowest estimate of genetic advance. Previous research by Golani *et al*. (2007) revealed high heredity for fruit weight, number of locules/ fruit, and yield of fruit. The no. of fruits/plant, average fruit wt, and fruit output her plant were found to have high heritability with strong genetic gain by Rai *et al*. (2016). Thus, these qualities could be improved via selection in the early generations.

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