Biological Forum – An International Journal 15(9): 872-881(2023)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Identification of Novel Genotypes Suitable for Processing in Tomato (*Solanum lycopersicum* L.) using Genetic variability Studies and Principal component Analysis

Ramavath Ramesh Babu[1*], Prasanna H.C.[2], J.S. Aravinda Kumar[3], Jyothi Kattegoudar[4], Ranjitha K.[5], S. Sriram[6], R.H. Laxman[7], K.V. Ravi Shankar[8] and C.N. Hanchinamani[9]

[1]Ph.D. Scholar, College of Horticulture, Bengaluru,
University of Horticultural Sciences, Bagalkot (Karnataka), India.
[2]Principal Scientist & Head,
Division of Vegetable Crops, Indian Institute of Horticultural Research, Bengaluru (Karnataka), India.
[3]Assistant Professor,
College of Horticulture, Mysore, University of Horticultural Sciences, Bagalkot (Karnataka), India.
[4]Assistant Professor,
College of Horticulture, Kolar, University of Horticultural Sciences, Bagalkot (Karnataka), India.
[5]Senior Scientist,
Division of Post-Harvest Technology, Indian Institute of Horticultural Research, Bengaluru (Karnataka), India.
[6]Principal Scientist & Head,
Division of Plant Pathology, Indian Institute of Horticultural Research, Bengaluru (Karnataka), India.
[7]Principal Scientist,
Division of Plant Physiology, Indian Institute of Horticultural Research, Bengaluru (Karnataka), India.
[8]Principal Scientist,
Division of Biotechnology, Indian Institute of Horticultural Research, Bengaluru (Karnataka), India.
[9]Professor & Head,
College of Horticulture, Bengaluru, University of Horticultural Sciences, Bagalkot (Karnataka), India.

(Corresponding author: Ramavath Ramesh Babu)*
(Received: 02 July 2023; Revised: 05 August 2023; Accepted: 06 September 2023; Published: 15 September 2023)
(Published by Research Trend)

ABSTRACT: This study used twenty one tomato genotypes and two check varieties and observations were taken for two seasons. Analysis of the coefficient of variation revealed that the magnitude of the PCV was slightly higher than the GCV for all the studied traits. Further, high estimates of heritability and genetic gain were recorded for lycopene and yield per plant. Twenty two components were identified based on the PCA with 24 attributes, although 7 PCs had more than 1 eigen value and 83.01% variability. Thus, suggesting that traits such as days to first fruit ripening, yield per plant and number of locules per fruit highest eigen vectors and factor loadings are responsible for genetic variability and divergence indicating that there is sufficient variation for the morphological traits observed in this principal component in the tomato parental lines that could be used to improve tomato cultivars for these traits.

Keywords: Genetic variability, GCV, PCV, heritability, genetic advance, PCA, principal component analysis, morphological, biochemical traits.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.; 2n=24) is the most widely grown and important vegetable crop in both tropical and sub-tropical regions. It ranks second in importance among vegetables after potato in production and consumption. Tomatoes are grown on 0.81 mha in India, with a production of 20.57 MT and average productivity of 22.7 t/ha (Anon., 2022). Tomatoes are an important source of lycopene (an antioxidant), ascorbic acid and β-carotene and are valued for their colour and flavour. Although tomatoes are commonly consumed fresh, over 80 per cent of tomato consumption comes from processed products such as tomato juice, paste, puree, ketchup and sauce (Takeoka *et al*., 2001). Quality and flavour of the processed products depend on chemical components like reducing sugar, acidity, ascorbic acid, lycopene, ß-carotene, T.S.S. and total sugar which has been reported to vary greatly with variety (Balasubramanian, 1984). High total soluble solids (4–8° Brix), acidity not less than 0.4%, pH less than 4.5, consistent red color, smooth surface, wrinkle-free, small core, firm flesh and uniform ripening are all desirable characteristics for a tomato cultivar to be used for processing (Adsule *et al*., 1980).

A limited supply of processing-type tomatoes is a major hurdle in the processing industry. Quality parameters for processing include colour, total soluble solids, sugar content and firmness for which existing Indian tomato varieties currently available in India are considered unsuitable.

The magnitude of variability and genetic components are the most important aspects of breeding material. Knowledge of genetic diversity, its nature and its degree is useful for selecting desirable parents from germplasm for the successful breeding programme. A great deal of information has been generated on the genetic variability of various components of tomato. Generally, the genotypic coefficient of variability (GCV) and phenotypic coefficient of variability (PCV) are measured to study the variability.

Principle component analysis (PCA) is a multivariate statistical method for exploring and simplifying large data sets, in which each principal component is a linear combination of the original variables, allowing the meaning of the components to be ascribed (Lewis and Lisle 1998). The PCA explains the relationship between the eigenvector and eigenvalues and economic yield and it aids in identifying the principal component of yield in diverse breeding populations. It aids in the development of selection criteria and the identification of superior lines in a large breeding population.

The objective of this study was to evaluate the genetic variability of tomato based on morphological and biochemical traits to develop processing suitable tomato hybrids and varieties with improvement in both yield and quality traits and also determine the usefulness of applying principal component analysis to evaluate morphological and biochemical traits that could be used in hybridization programme for choice of parent would lead to improvement in yield and quality of tomato.

MATERIAL AND METHODS

The experimental material consists of 21 parents and 2 checks (Arka Apeksha and Arka Vishesh) (Table 1), comprising germplasm, advanced breeding lines and cultivars from different sources evaluated for processing traits in summer and rabi seasons during 2020. The experiment was set up in a randomized complete block design (RCBD) with 3 replications. The experiment was carried out at the Indian Institute of Horticultural Research (IIHR), Hessaraghatta, Bangalore (Karnataka) at an experimental plot (Block-8) division of vegetable crops. The experimental site is located at an altitude of 930 meters above mean sea level (MSL)

and 130 N latitude and 77.370 E longitude in the Eastern Dry Zone of Karnataka (Zone-5). The observations were recorded for two season (summer and rabi seasons during 2020) pooled 24 quantitative and qualitative characters viz., plant height (cm), days to 50 per cent flowering, days to first fruit ripening, number of fruits per cluster, fruit length (cm), fruit width (cm), Pericarp thickness (mm), number of locules per fruit, number of seeds per fruit, size of the core in fruit cross section (mm), peduncle scar size (mm), TSS (°Brix), firmness (kg/ cm^2), number of fruits per plant, average fruit weight (g), yield per plant (Kg), pulp recovery (%), moisture (%), p^H, titrable acidity (%), vitamin C (mg), carotenoids(mg), lycopene (mg) and shelf life (days) in five randomly selected plants from each genotype in each replication.

The analysis of variance for the design of the experiment was done by partitioning the variance into treatments and replications. Genotypic and phenotypic coefficients of variance were estimated according to Burton (1952) based on an estimate of genotypic and phenotypic variance. The broad sense heritability was estimated by following the procedure suggested by Hanson *et al*. (1956). Genetic advance as a percent of the mean was calculated as per the formula given by Jhonson *et al*. (1955). Principal Component (PC) Analysis was performed on the collected data for each trait under study, using Indostat services, Hyderabad.

RESULTS AND DISCUSSION

In the present investigation, the analysis of variance for 24 characters studied, was significantly different between the genotypes, revealing the vast range of variation between the genotypes (Table 2). For each of the twenty-four characters tested, the analysis of variance indicated wide variability among the genotypes. This information suggests that a considerable amount of variation persists for all the characters and considerable improvement can be achieved by selection for these genotypes. These results were in accordance with the results reported by Sonam and Sanjeev (2017) in tomato.

The *per se* performance of the genotypes revealed a wide range of variation (Table 3) for traits. Earliness is one of the most desirable parameters, as early crop produce can benefit the farmer and consumers when the demand is high. Earliness is determined by two traits such as days to 50 per cent flowering and days to first fruit ripening. The genotypes like PED (24.31), IIHR-2833 (26.83) and IIHR-2955 (27.00) took minimum days to 50 per cent flowering and the genotypes like PED (68.67), IIHR-2957 (71.4) and CLN3916D (72.17) took minimum days to first fruit ripening. These results were in accordance with the results of Kumari *et al*. (2020).

The genotype CLN3961D (7.78mm), IIHR-2833 (7.60mm) and IIHR-Sel-41-1(7.25mm) had maximum pericarp thickness. The genotypes IIHR-2955 (2.51), IIHR-2784 (2.66) and CLN3916D (3.00) had less number of locules per fruit. The genotypes IIHR-2273 (30.76), IIHR-2847 (31.79) and IIHR-2834 (37.20) had less number of seeds per fruit among the 23 genotypes. The genotypes IIHR-2273 (14.59mm), PED (20.07mm) and IIHR-2834 (21.40mm) had low size of core in fruit cross section. The genotypes IIHR-2957 (5.64), IIHR-2327-1 (5.34) and IIHR-TLBER-7-4-11-34 (5.20) had maximum TSS (°Brix). The genotypes IIHR-2784 (7.52), IIHR-Sel-57 (6.96) and IIHR-Sel-19 (6.87) had maximum firmness. The maximum number of fruits per plant was observed in the genotypes IIHR-2955 (90.07), PED (89.28) and IIHR-2273 (72.90). The genotypes IIHR-2327-1 (145.80g), IIHR-2698 (127.30g) and IIHR-Sel-41-1 (123.73g) had maximum average fruit weight. The genotypes IIHR-2955 (5.70kg), IIHR-Sel-22 (5.41kg) and IIHR-2847 (5.01 kg) had maximum yield per plant. Pulp recovery was found to be highest in the genotypes IIHR-2784 (96.96 %), IIHR-Sel-41-1 (96.69 %) and IIHR-Sel-57 (96.65 %). These results were in agreement with the results of Kavyashree *et al*. (2017a); Kaushal *et al*. (2017); Kumari *et al*. (2020); Rawat *et al*. (2020).

The genotypes IIHR-2833 (4.49), IIHR-2273 (4.47) and IIHR-2834 (4.40) had maximum P^H. Maximum vitamin C was observed in the genotypes IIHR-2327-1 (35.88 %), IIHR-2957 (35.45 %) and IIHR-2411-2 (32.54 %). The maximum carotenoids were recorded in the genotypes IIHR-2273 (24.77 mg), IIHR-Sel-19 (24.02 mg) and IIHR-2327-1(18.16 mg). Lycopene content was found to be highest in the genotypes IIHR-Sel-19 (21.38 mg), IIHR-2273 (21.02 mg) and IIHR-TLBER-7-4-11-34 (16.72 mgs). Among 23 genotypes IIHR-TLBER-7-4-11-34 (29.33), IIHR-2327-1 (24.00) and CLN3916D (23.50) were found to have maximum shelf life. Similar results were recorded by Rai *et al*., (2016); Bhandari *et al*. (2017); Panchbhaiya *et al*. (2018); Kumari *et al*. (2020).

Twenty three genotypes from diverse sources were evaluated in the present study and their results reveal that the PCV values were higher than their respective GCV values indicating a slight environmental effect on expression of traits (Table 4 and Fig. 1). Both GCV and PCV were found to be highest for lycopene (45.05% and 45.26%), number of seeds per fruit (33.28% and 34.42%), yield per plant (33.30% and 33.51%), titrable acidity (30.92% and 31.31%) and number of locules per fruit (23.33% and 24.93%). The traits like fruit length (16.06% and 16.71%), fruit width (12.30% and 13.37%), fruits per cluster (11.61% and 12.59%) and pericarp thickness (11.41% and 13.46%) had moderate genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV). Whereas, the traits like days to 50 per cent flowering (8.27% and 8.86%), days to first fruit ripening (7.59% and 7.92%), pH (4.38% and 5.01%) and TSS (3.80% and 4.93%) had lowest PCV and GCV. From these results, it is understood that most of the traits have high GCV and PCV which is evident in the contribution of genetic components or the total variation as well as presence of environment effect in expression of these characters which suggests that these genetic material have ample scope for improvement of these traits in successive filial generations by phenotype based screening. Similar results on yield and yield components in tomato were observed by Taiana *et al*. (2015); Prajapati *et al*. (2015); Kumar *et al*. (2018); Rai *et al*. (2016); Patel *et al*. (2017); Dutta *et al*. (2018); Kumari *et al*. (2020) for lycopene, carotenoids, number of fruits per plant, yield per plant, titrable acidity, vitamin C, number of locules per fruit, average fruit weight, shelf life and fruit firmness.

Highest heritability was recorded for lycopene (99.10%), yield per plant (98.80%), firmness (97.90%), titrable acidity (97.50%) and number of seeds per fruit (97.50%). Whereas the traits like pericarp thickness (71.80%) and TSS (59.20%) had moderate heritability (h^2). The high heritability in broad sense indicated that these traits are less influenced by environment. High heritability was also found by Sureshkumara *et al*. (2018); Bhandari *et al*. (2017); Anuradha *et al*. (2020) for yield; Thapa *et al*. (2016); Kumari *et al*. (2020) for days to first flowering; Meitei *et al*. (2014); Bhuiyan *et al*. (2016); Dutta *et al*. (2018); Kaushal *et al*. (2019); Rawat *et al*. (2020); Ligade *et al*. (2017); Sherpa *et al*. (2014); Basavaraj *et al*. (2015); Kumari *et al*. (2020) for polar diameter. Dutta *et al*. (2018); Kaushal *et al*. (2017); Sureshkumara *et al*. (2018) for titrable acidity; Shankar *et al*. (2013), Sherpa *et al*. (2014); Meena and Bahadur (2014) for ascorbic acid; Sherpa *et al*. (2014), Basavaraj *et al*. (2015), Rai *et al*. (2016); Ligade *et al*. (2017); Dutta *et al*. (2018) for lycopene content; Dar and Sharma (2011); Kumari *et al*. (2020) for beta carotene content.

The traits like fruit weight (42.51%), number of seeds per fruit (33.37%) and pulp recovery (32.05%) had highest genetic advancement. Whereas, the traits like plant height (16.10%), vitamin C (14.16%) and carotenoids (11.18%) had moderate genetic advancement and the traits like yield per plant (3.43%), TSS (0.31%) and titrable acidity (0.24%) had less genetic advancement. High estimates of genetic advance as per cent mean (GAM) was observed in lycopene (92.38%), number of seeds per fruit (66.28%), yield per plant (68.19%), titrable acidity (62.89%) and number of locules (44.96%). This suggests that these traits are governed by additive gene action and selection would be effective for such characters. Also, improvement of these characters could possibly be done due to minimal alteration in performance by the influence of the environment. Pericarp thickness (19.92%), plant height (17.04%), days to 50 percent flowering (15.89%) and days to first fruit ripening (14.99%) had moderate level of GAM indicating that these traits are governed by non-additive gene action coupled with non-allelic inter-locus effect. Hence simple selection might not be possible solution to obtain an enhanced manifestation of these traits in desired direction. Therefore, hybridization followed by selection in advanced generation could be adopted as a strategy. Similar finding was also observed by Shankar *et al*. (2013); Kavyashree *et al*. (2017) for TSS. Whereas p^H, moisture, and TSS (°Brix) had lowest genetic advance as percent mean (GAM). There was an evidence of low variability and this might be due to the action of non-additive genes. These results corroborated with the results of Bhandari *et al*. (2017); Aralikatti *et al*. (2018); Rai *et al*. (2016); Prajapati *et al*. (2015); Ligade *et al*. (2017); Kaushal *et al*. (2019); Panchbhaiya *et al*. (2018); Dutta *et al*. (2018).

The results of PCA in the present study were used to determine which traits were the major sources of variation within the parental lines which revealed that the present data was divided into twenty-two principal components which were also referred to as factors here (Table 5, 6, 7 and Fig. 2). Among them four principal components PC1, PC2, PC3 and PC4 with highest eigenvalues and total cumulative variability are desirable. Out of twenty two factors, the first seven principal components PC1, PC2, PC3, PC4, PC5, PC6 and PC7 showed eigenvalues of more than one and cumulatively they explained 83.01% variability. The contribution of first PC1 towards variability was highest. The traits like average fruit weight (0.381 and 0.909), fruit width (0.317 and 0.756), size of the core in fruit cross section (0.297 and 0.708) and peduncle scar size (0.300 and 0.715) had highest eigenvectors, factor loadings in PC1. The second principal component PC2 illustrated second highest total variability. The most important traits in this component were pulp recovery (0.405 and 0.812), days to first fruit ripening (0.214 and 0.429) and moisture content (0.212 and 0.425) had highest eigenvectors factor loadings in PC2. The third and fourth principal components PC3, PC4 had total variability next to PC1 and PC2. The most important traits in this component were fruit length (0.383 and 0.696), yield per plant (0.301 and 0.546) and days to first fruit ripening (0.288 and 0.53) for PC3. The traits such as yield per plant (0.497 and 0.754), number of fruits per plant (0.383 and 0.581) and number of locules per fruit (0.306 and 0.464) for PC4 had highest eigen vectors and factor loadings. This suggested that these four factors are more responsible for genetic variation and the traits that contributed more eigen vectors and factor loadings are responsible for genetic variability and divergence. This clearly indicated that there is sufficient variation for the morphological traits observed in the four principal components in the tomato parental lines that could be used to improve tomato cultivars for these traits. Ghosh *et al*. (2009) observed that the first two principal axes accounted for 60% of the total variation among the 22 traits describing F_2 populations of 40 exotic tomato hybrids. Similarly, Merk *et al*. (2012) reported that the first three PCs explained 57.1% of the total variation for 143 processing tomato genotypes evaluated in North America. Cumulatively, the first two PCs explained 50.93% of the variation in study of Chernet *et al*. (2014). Similar results were also observed by Meena and Bahadur (2017).

Table 1: List of parental lines/genotypes used in this study.

Sr. No.	Genotype	Source
1.	IIHR-2957	IIHR-Bengaluru
2.	IIHR-2411-2	IIHR-Bengaluru
3.	IIHR-2833	IIHR-Bengaluru
4.	IIHR-2273	IIHR-Bengaluru
5.	IIHR-2834	IIHR-Bengaluru
6.	IIHR-2327-1	IIHR-Bengaluru
7.	IIHR-2847	IIHR-Bengaluru
8.	IIHR-2955	IIHR-Bengaluru
9.	IIHR-2821	IIHR-Bengaluru
10.	IIHR-2698	IIHR-Bengaluru
11.	IIHR-2784	IIHR-Bengaluru
12.	TLBER-7-4-11-34	IIHR-Bengaluru
13.	IIHR - Sel.19	IIHR-Bengaluru
14.	IIHR - Sel.22	IIHR-Bengaluru
15.	IIHR - Sel.57	IIHR-Bengaluru
16.	IIHR - Sel.41-1	IIHR-Bengaluru
17.	Arka Ashish	IIHR-Bengaluru
18.	Arka Ahuthi	IIHR-Bengaluru
19.	Pusa early dwarf	IARI-New Delhi
20.	CLN3916C	AVRDC-Taiwan
21.	CLN3916D	AVRDC-Taiwan
22.	Arka Apeksha	IIHR-Bengaluru
23.	Arka Vishesh	IIHR-Bengaluru

Table 2: Analysis of variance (ANOVA) of parents for growth, yield and quality attributes in tomato for pooled season.

Sr. No.	Source of variation	Replications	Treatment	Environment	Trt x Env	Error
	DF	**2**	**22**	**1**	**22**	**90**
1.	Plant height (cm)	36.371	291.193 **	0.394	187.095 **	22.74
2.	Days to 50 % flowering	2.629	13.199 **	0.052	24.485 **	1.067
3.	Days to first fruit ripening	0.373	96.966 **	6.136	119.116 **	2.771
4.	Number of fruits per cluster	0.469 **	1.051 **	0.072	1.098 **	0.07
5.	Fruit length (cm)	0.139	2.644 **	0.001	2.175 **	0.057
6.	Fruit width (cm)	0.012	1.571 **	0.009	1.015 **	0.085
7.	Pericarp thickness (mm)	2.783 **	1.586 **	0.01	2.124 **	0.228
8.	Number of locules per fruit	0.133	2.425 **	0.028	1.884 **	0.113
9.	Number of seeds per fruit	39.656	1022.236 **	71.755	704.109 **	19.081
10.	Size of core in fruit cross section (mm)	10.757	129.845 **	3.441	64.729 **	5.681
11.	Peduncle scar size (mm)	8.945 **	30.232 **	0.145	31.134 **	0.727
12.	TSS (°Brix)	0.002	0.134 **	0.023	0.131 **	0.028
13.	Firmness (kg/ cm^2)	0.014	5.942 **	0.018	2.307 **	0.033
14.	Number of fruits per plant	73.890 **	1653.099 **	4.682	978.178 **	13.228
15.	Average fruit weight (g)	112.967	1772.495 **	2.674	1062.544 **	43.977
16.	Yield per plant (Kg)	0.347 **	11.053 **	0.009	5.830 **	0.039
17.	Pulp recovery (%)	5.026	1364.222 **	26.366 *	173.985 **	4.256
18.	Moisture (%)	88.631 **	52.827 **	3.91	34.715 **	6.231
19.	p^H	0.01	0.165 **	0	0.053 **	0.012
20.	Titrable acidity (%)	0.001	0.052 **	0	0.033 **	0
21.	Vitamin C (mg)	9.108	193.233 **	0.03	109.944 **	2.998
22.	Carotenoids(mg)	1.12	128.838 **	0.25	51.914 **	0.66
23.	Lycopene (mg)	3.883 **	97.405 **	0	42.851 **	0.239
24.	Shelf life (days)	24.225 **	75.098 **	0.116	40.222 **	1.588

*Significant at 5 per cent level; ** Significant at 1 per cent level Values in parenthesis indicating degrees of freedom

Table 3a: *Per se* performance of parents for growth, yield and quality attributes in tomato for pooled season.

Sr. No.	Parents	Plant height (cm)	Days to 50 percent flowering	Days to first fruit ripening	Number of fruits per cluster	Fruit length (cm)	Fruit width (cm	Pericarp thickness (mm)
1.	IIHR-2957	97.37	28.00	71.42	4.35	3.83	5.55	5.86
2.	IIHR-2411-2	89.75	35.00	79.17	5.01	5.67	6.25	6.98
3.	IIHR-2833	96.87	26.83	75.16	4.87	5.78	5.22	7.60
4.	IIHR-2273	89.03	32.33	81.17	6.12	7.06	4.82	6.69
5.	IIHR-2834	98.33	32.83	81.17	4.46	5.44	4.60	6.95
6.	IIHR-2327-1	104.07	31.17	77.33	4.60	4.99	6.23	5.17
7.	IIHR-TLBER-7-4-11-34	93.73	31.67	81.33	4.44	5.29	5.88	6.28
8.	IIHR-2847	92.50	31.06	76.26	6.23	4.24	5.36	5.74
9.	IIHR-2955	91.04	27.00	74.03	6.19	5.08	4.44	5.71
10.	IIHR-2821	87.04	27.17	73.67	5.22	5.23	5.03	7.25
11.	IIHR-2698	91.68	29.17	79.83	4.26	5.57	5.92	7.33
12.	IIHR-SEL-19	104.26	30.50	75.67	5.81	6.30	5.05	6.89
13.	IIHR-SEL-22	96.87	28.00	75.50	4.73	6.26	4.52	6.60
14.	IIHR-SEL-57	109.27	31.33	77.67	4.61	5.54	4.85	6.54
15.	IIHR-SEL-41-1	114.60	31.67	88.67	4.60	6.92	5.92	7.25
16.	Arka Ashish	76.86	27.17	73.50	5.35	6.15	4.83	6.54
17.	Arka Ahuthi	87.99	31.26	77.33	4.73	6.10	4.06	6.73
18.	PED	85.66	24.31	68.67	4.59	3.47	4.25	5.35
19.	CLN3916C	86.90	30.33	74.50	5.30	5.35	4.87	5.79
20.	CLN3916D	81.18	27.33	72.17	5.06	5.35	5.67	7.78
21.	IIHR-2784	95.33	31.83	97.17	4.95	5.49	5.08	5.83
22.	Arka Vishesh (Check-1)	102.53	29.17	76.83	5.46	6.51	5.70	7.41
23.	Arka Apeksha (Check-2)	100.61	30.50	75.83	5.42	4.68	6.16	5.48
	Mean	94.50	29.81	77.57	5.06	5.49	5.23	6.51
	C.V.	4.59	3.18	2.25	4.88	4.59	5.23	7.14
	S.E.	1.77	0.39	0.71	0.10	0.10	0.11	0.19
	C.D. 5%	4.96	1.09	2.00	0.28	0.29	0.31	0.53

Table 3b: *Per se* performance of parents for growth, yield and quality attributes in tomato for pooled season.

Sr. No.	Parents	Number of locules per fruit	Number of seeds per fruit	Size of core in fruit cross section (mm)	Peduncle scar size (mm)	TSS (°Brix)	Firmness (kg/ cm^2)	Number of fruits per plant
1.	IIHR-2957	4.57	74.27	28.60	10.42	5.64	4.66	52.80
2.	IIHR-2411-2	4.80	42.50	26.69	16.48	4.93	3.85	48.55
3.	IIHR-2833	3.03	49.46	25.92	6.17	5.36	5.18	51.63
4.	IIHR-2273	3.14	30.76	14.59	4.91	4.76	3.42	72.90
5.	IIHR-2834	3.11	37.20	21.40	8.14	5.17	5.56	53.54
6.	IIHR-2327-1	5.83	70.47	33.04	16.44	5.34	4.80	34.06
7.	IIHR-TLBER-7-4-11-34	3.40	51.30	31.55	6.34	5.20	6.01	49.19
8.	IIHR-2847	3.42	31.79	25.39	7.96	5.20	5.85	69.16
9.	IIHR-2955	2.51	41.06	25.67	6.81	5.30	5.97	90.07
10.	IIHR-2821	3.31	41.60	27.90	6.51	5.26	5.57	65.24
11.	IIHR-2698	4.20	58.06	37.74	10.94	5.15	5.98	47.79
12.	IIHR-SEL-19	3.91	46.69	38.30	10.62	5.11	6.87	39.20
13.	IIHR-SEL-22	3.06	43.98	23.55	5.64	4.85	6.40	67.06
14.	IIHR-SEL-57	4.09	50.14	29.27	11.38	4.86	6.96	35.28
15.	IIHR-SEL-41-1	4.33	41.91	29.41	9.32	4.94	6.26	31.69
16.	Arka Ashish	3.07	44.46	24.52	7.99	4.91	5.24	60.76
17.	Arka Ahuthi	2.29	28.29	19.80	5.37	5.09	4.64	53.68
18.	PED	3.66	56.91	20.07	5.63	4.82	3.16	89.28
19.	CLN3916C	3.25	90.41	22.14	8.43	5.04	5.83	54.16
20.	CLN3916D	3.00	91.10	21.82	10.55	5.08	6.18	48.77
21.	IIHR-2784	2.66	40.21	29.33	6.15	5.04	7.52	47.72
22.	Arka Vishesh (Check-1)	3.04	45.34	21.65	5.88	5.08	7.04	104.87
23.	Arka Apeksha (Check-2)	4.61	49.99	23.00	9.26	5.15	7.19	105.94
	Mean	3.58	50.34	26.14	8.58	5.10	5.66	59.71
	C.V.	8.79	8.79	8.53	9.51	3.15	3.03	5.57
	S.E.	0.13	1.81	0.91	0.33	0.07	0.07	1.36
	C.D. 5%	0.36	5.06	2.55	0.93	0.18	0.20	3.80

Table 3c: ***Per se*** **performance of parents for growth, yield and quality attributes in tomato for pooled season.**

Sr. No.		Average fruit weight (g)	Yield per plant (Kg)	Pulp recovery (%)	Moisture (%)	p^H	Titrable acidity (%)	Vitamin C (mg/100 g)
1.	IIHR-2957	88.26	3.65	78.96	82.61	4.33	0.23	35.45
2.	IIHR-2411-2	117.07	5.36	76.05	92.54	4.18	0.34	32.54
3.	IIHR-2833	90.29	4.85	68.66	92.66	4.49	0.24	36.53
4.	IIHR-2273	81.54	4.97	47.70	93.35	4.47	0.34	27.32
5.	IIHR-2834	86.30	4.23	57.08	94.09	4.40	0.30	21.36
6.	IIHR-2327-1	145.80	4.58	58.74	94.15	4.37	0.40	35.88
7.	IIHR-TLBER-7-4-11-34	114.18	4.59	61.62	92.20	4.43	0.24	32.24
8.	IIHR-2847	70.60	5.01	59.57	87.96	4.14	0.41	26.72
9.	IIHR-2955	65.96	5.70	67.60	84.31	4.11	0.27	29.12
10.	IIHR-2821	75.93	4.56	61.77	92.30	4.12	0.26	32.00
11.	IIHR-2698	127.30	5.00	58.96	93.08	4.36	0.36	23.48
12.	IIHR-SEL-19	114.38	4.68	55.47	88.03	4.39	0.33	25.63
13.	IIHR-SEL-22	84.53	5.41	70.83	80.87	4.37	0.34	17.92
14.	IIHR-SEL-57	103.70	3.90	96.65	93.37	3.97	0.52	27.70
15.	IIHR-SEL-41-1	123.73	4.71	96.69	93.81	4.05	0.60	22.76
16.	Arka Ashish	88.65	4.21	96.59	91.95	4.00	0.31	14.84
17.	Arka Ahuthi	65.46	3.47	93.87	92.28	3.96	0.61	26.07
18.	PED	60.40	4.40	90.77	92.58	4.16	0.41	23.92
19.	CLN3916C	81.75	4.26	88.88	90.79	4.02	0.33	28.68
20.	CLN3916D	93.19	3.87	87.12	92.50	4.11	0.46	27.02
21.	IIHR-2784	86.20	4.20	96.96	94.08	3.80	0.59	21.24
22.	Arka Vishesh (Check-1)	95.67	9.97	71.76	92.77	4.18	0.54	10.15
23.	Arka Apeksha (Check-2)	93.00	10.12	74.03	91.56	4.27	0.43	13.33
	Mean	93.65	5.03	74.62	91.04	4.20	0.38	25.73
	C.V.	6.74	3.68	3.85	2.60	2.42	4.96	6.31
	S.E.	2.58	0.08	1.17	0.97	0.04	0.01	0.66
	C.D. 5%	7.23	0.21	3.28	2.71	0.12	0.02	1.86

Table 3d: ***Per se*** **performance of parents for growth, yield and quality attributes in tomato for pooled season.**

Sr. No.		Carotenoids (mg/100 g)	Lycopene (mg/100 g)	Shelf life (days)
1.	IIHR-2957	10.80	8.66	21.17
2.	IIHR-2411-2	12.04	11.03	22.33
3.	IIHR-2833	9.55	9.03	22.83
4.	IIHR-2273	24.77	21.02	19.83
5.	IIHR-2834	13.86	10.66	18.67
6.	IIHR-2327-1	18.16	14.98	24.00
7.	IIHR-TLBER-7-4-11-34	18.02	16.72	29.33
8.	IIHR-2847	17.51	13.12	19.83
9.	IIHR-2955	15.04	14.08	15.83
10.	IIHR-2821	9.71	10.61	20.33
11.	IIHR-2698	15.42	11.36	19.33
12.	IIHR-SEL-19	24.02	21.38	19.83
13.	IIHR-SEL-22	14.85	13.83	17.33
14.	IIHR-SEL-57	7.87	6.29	20.33
15.	IIHR-SEL-41-1	11.94	11.20	18.67
16.	Arka Ashish	12.10	8.98	19.67
17.	Arka Ahuthi	5.93	5.32	13.33
18.	PED	6.53	5.29	10.50
19.	CLN3916C	5.97	4.43	22.83
20.	CLN3916D	8.19	6.43	23.50
21.	IIHR-2784	3.41	2.87	31.17
22.	Arka Vishesh (Check-1)	10.44	8.65	20.50
23.	Arka Apeksha (Check-2)	11.95	10.57	20.17
	Mean	12.52	10.72	20.49
	C.V.	6.04	4.32	5.62
	S.E.	0.31	0.19	0.47
	C.D. 5%	0.87	0.53	1.32

Table 4a: Genetic parameters of variability for growth, yield, and quality traits in tomato for pooled season.

Genetic Parameters	GCV (%)	PCV (%)	h^2 (Broad Sense) (%)	GA (5%)	GAM (5%)
Plant height (cm)	9.24	10.31	80.20	16.10	17.04
Days to 50 percent flowering	8.27	8.86	87.10	4.74	15.89
Days to first fruit ripening	7.59	7.92	91.90	11.63	14.99
Number of fruits per cluster	11.61	12.59	85.00	1.12	22.04
Fruit length (cm)	16.06	16.71	92.40	1.75	31.81
Fruit width (cm)	12.30	13.37	84.70	1.22	23.32
Pericarp thickness (mm)	11.41	13.46	71.80	1.30	19.92
Number of locules per fruit	23.33	24.93	87.60	1.61	44.96
Number of seeds per fruit	33.28	34.42	93.50	33.37	66.28
Size of core in fruit cross section (mm)	21.41	23.04	86.30	10.71	40.96
peduncle scar size (mm)	36.94	38.15	93.80	6.32	73.70
TSS (°Brix)	3.80	4.93	59.20	0.31	6.02
Firmness (kg/ cm^2)	20.67	20.89	97.90	2.38	42.13
Number of fruits per plant	34.99	35.43	97.50	42.50	71.17

Table 4b: Genetic parameters of variability for growth, yield, and quality traits in tomato for pooled season.

Genetic Parameters	GCV (%)	PCV (%)	h^2 (Broad Sense) (%)	GA (5%)	GAM (5%)
Average fruit weight (g)	22.96	23.93	92.10	42.51	45.39
Yield per plant (Kg)	33.30	33.51	98.80	3.43	68.19
Pulp recovery (%)	21.19	21.54	96.80	32.05	42.95
Moisture (%)	3.96	4.74	69.90	6.22	6.83
p^H	4.38	5.01	76.70	0.33	7.90
Titrable acidity (%)	30.92	31.31	97.50	0.24	62.89
Vitamin C (mg/100g)	27.40	28.12	95.00	14.16	55.01
Carotenoids(mg/100g)	43.72	44.14	98.10	11.18	89.22
Lycopene (mg/100g)	45.05	45.26	99.10	9.90	92.38
Shelf life (days)	21.23	21.96	93.50	8.66	42.27

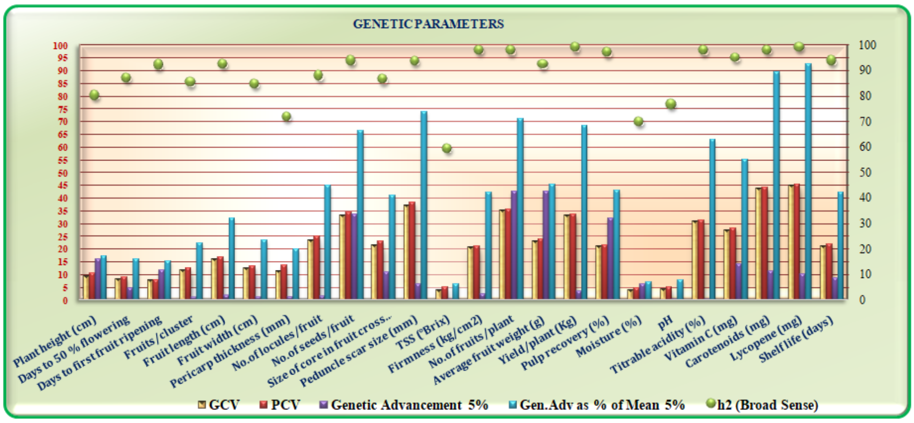

Fig. 1. Estimation of variability, heritability, genetic advance and genetic advance as percent mean for 24 traits in 23 genotypes of tomato for pooled data.

Fig. 2. Principal Scree plot between component and eigen value.

Table 5: Eigen value and contribution of the principal component axes towards variation in tomato genotypes.

Principal Component	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Eigenvalue	5.688	4.012	3.299	2.300	1.778	1.535	1.310	0.965	0.708	0.553
Variability (%)	23.702	16.717	13.747	9.581	7.409	6.394	5.456	4.022	2.950	2.304
Cumulative (%)	23.702	40.419	54.166	63.747	71.156	77.550	83.007	87.028	89.978	92.282

Table 6: Contribution of different quantitative and processing traits of tomato towards major principal components.

Sr. No.	Eigenvectors	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
1.	Plant height (cm)	0.228	0.072	0.190	0.133	-0.050	0.214	-0.403	-0.155	0.353	0.104
2.	Days to 50 percent flowering	0.241	0.083	0.199	-0.109	-0.232	-0.347	-0.021	0.081	0.295	0.189
3.	Days to first fruit ripening	0.160	0.214	0.288	-0.187	-0.114	-0.294	-0.087	-0.248	-0.157	0.124
4.	Number of fruits per cluster	-0.098	-0.243	0.202	0.066	0.085	-0.357	0.022	0.523	-0.084	-0.148
5.	Fruit length (cm)	0.064	0.041	0.383	-0.279	-0.041	0.243	0.157	0.251	-0.038	0.233
6.	Fruit width (cm)	0.317	0.032	0.022	0.290	0.020	-0.056	0.303	-0.026	0.009	-0.095
7.	Pericarp thickness (mm)	0.007	0.069	0.176	-0.262	0.147	0.478	0.373	0.134	0.210	-0.225
8.	Number of locules per fruit	0.296	0.023	-0.196	0.306	-0.228	0.054	-0.087	0.055	0.077	-0.014
9.	Number of seeds per fruit	0.069	0.107	-0.326	0.194	0.239	0.075	0.284	0.232	-0.107	0.475
10.	Size of core in fruit cross section (mm)	0.297	0.052	-0.083	-0.029	0.215	0.143	-0.284	-0.071	-0.381	-0.436
11.	Peduncle scar size (mm)	0.300	0.097	-0.188	0.157	-0.139	-0.030	0.017	0.386	0.070	-0.105
12.	Firmness (kg/cm^2)	0.086	0.154	0.282	0.148	0.481	0.081	-0.177	-0.029	-0.131	-0.007
13.	Number of fruits per plant	-0.250	-0.198	0.156	0.383	-0.006	-0.093	0.114	-0.126	0.024	-0.084
14.	Average fruit weight (g)	0.381	0.101	-0.011	0.086	-0.083	0.183	0.049	0.066	-0.160	0.031
15.	Yield per plant (Kg)	-0.008	-0.099	0.301	0.497	0.039	0.009	0.156	-0.099	0.136	-0.079
16.	Pulp recovery (%)	-0.160	0.405	-0.071	0.048	-0.004	0.054	-0.049	0.136	-0.024	0.171
17.	Moisture (%)	0.062	0.212	0.074	-0.059	-0.374	-0.067	0.450	-0.162	-0.168	-0.384
18.	p^H	0.165	-0.350	-0.024	-0.011	-0.065	0.220	0.195	-0.371	0.111	0.264
19.	TSS (°Brix)	0.229	-0.029	0.079	-0.103	0.425	-0.182	0.081	0.070	0.464	-0.181
20.	Titrable acidity (%)	-0.051	0.350	0.236	0.115	-0.202	0.040	-0.110	0.166	0.054	0.010
21.	Vitamin C (mg/100 g)	0.137	-0.082	-0.360	-0.271	0.020	-0.177	-0.019	-0.030	0.291	-0.146
22.	Carotenoids (mg/100g)	0.201	-0.381	0.129	-0.070	-0.117	0.033	-0.067	0.157	-0.221	0.108
23.	Lycopene (mg/100 g)	0.201	-0.380	0.139	-0.090	-0.093	0.055	-0.084	0.134	-0.195	0.060
24.	Shelf life (days)	0.232	0.129	0.044	-0.069	0.312	-0.353	0.246	-0.229	-0.225	0.210

Table 7: Contribution of different quantitative and processing traits of tomato towards factor loadings.

Sr. No.	Factor loadings	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
1.	Plant height (cm)	0.543	0.144	0.345	0.201	-0.067	0.265	-0.461	-0.153	0.297	0.077
2.	Days to 50 percent flowering	0.576	0.165	0.361	-0.166	-0.309	-0.430	-0.024	0.080	0.248	0.140
3.	Days to first fruit ripening	0.382	0.429	0.523	-0.283	-0.153	-0.364	-0.099	-0.244	-0.132	0.092
4.	Number of fruits per cluster	-0.233	-0.487	0.367	0.101	0.114	-0.442	0.025	0.514	-0.071	-0.110
5.	Fruit length (cm)	0.152	0.082	0.696	-0.424	-0.055	0.301	0.180	0.247	-0.032	0.173
6.	Fruit width (cm)	0.756	0.065	0.039	0.439	0.027	-0.069	0.347	-0.026	0.007	-0.071
7.	Pericarp thickness (mm)	0.017	0.139	0.320	-0.397	0.196	0.592	0.427	0.132	0.177	-0.168
8.	Number of locules per fruit	0.705	0.046	-0.356	0.464	-0.304	0.067	-0.099	0.054	0.065	-0.010
9.	Number of seeds per fruit	0.164	0.214	-0.593	0.295	0.319	0.093	0.325	0.228	-0.090	0.353
10.	Size of the core in fruit cross section (mm)	0.708	0.103	-0.151	-0.043	0.286	0.177	-0.325	-0.070	-0.321	-0.325
11.	Peduncle scar size (mm)	0.715	0.195	-0.341	0.238	-0.185	-0.038	0.019	0.379	0.059	-0.078
12.	Firmness (kg/cm^2)	0.204	0.309	0.513	0.225	0.641	0.100	-0.203	-0.028	-0.110	-0.006
13.	Number of fruits per plant	-0.595	-0.397	0.282	0.581	-0.008	-0.116	0.130	-0.123	0.020	-0.063
14.	Average fruit weight (g)	0.909	0.203	-0.020	0.131	-0.110	0.227	0.056	0.065	-0.135	0.023
15.	Yield per plant (Kg)	-0.019	-0.199	0.546	0.754	0.053	0.012	0.179	-0.097	0.114	-0.059
16.	Pulp recovery (%)	-0.381	0.812	-0.129	0.072	-0.005	0.067	-0.056	0.133	-0.020	0.127
17.	Moisture (%)	0.147	0.425	0.135	-0.089	-0.498	-0.083	0.515	-0.159	-0.141	-0.285
18.	p^H	0.395	-0.701	-0.043	-0.016	-0.087	0.272	0.223	-0.364	0.093	0.196
19.	TSS (°Brix)	0.545	-0.057	0.143	-0.156	0.567	-0.226	0.093	0.069	0.391	-0.134
20.	Titrable acidity (%)	-0.122	0.701	0.429	0.174	-0.269	0.050	-0.125	0.163	0.046	0.007
21.	Vitamin C (mg/100g)	0.327	-0.165	-0.654	-0.410	0.027	-0.219	-0.021	-0.029	0.245	-0.109
22.	Carotenoids (mg/100g)	0.480	-0.763	0.234	-0.106	-0.156	0.041	-0.076	0.154	-0.186	0.081
23.	Lycopene (mg/100g)	0.479	-0.761	0.252	-0.137	-0.124	0.068	-0.097	0.131	-0.164	0.045
24.	Shelf life (days)	0.553	0.258	0.079	-0.105	0.416	-0.437	0.281	-0.225	-0.189	0.156

CONCLUSIONS

The analysis of 21 parental lines and 2 check varieties of tomatoes revealed a wide range of variability for different morphological and biochemical traits. Parental lines used were completely determinate, which will reduce the number of harvests, unlike semi-determinate. Days to 50% flowering, days to first fruit ripening, pericarp thickness, number of locules and number of seeds per fruit, size of core in fruit cross-section, yield per plant, TSS, fruit firmness, titrable acidity, lycopene, p^H, pulp recovery, carotenoids, and shelf life are the most significant traits for which direct selection may result in appreciable improvement in selecting superior tomato genotypes.

The present data was divided into twenty-two principal components. Out of twenty two factors, the first seven principal components PC1, PC2, PC3, PC4, PC5, PC6 and PC7 showed eigenvalues of more than one and cumulatively they explained 83.01% variability, thus suggesting that traits such as fruit weight, fruit width, size of core in fruit cross section, pulp recovery, days to first fruit ripening, moisture content, yield per plant, number of fruits per plant and number of locules per fruit with highest eigen vectors and factor loadings were the principal differentiating traits. So, while applying these traits in a tomato breeding program, it is important to consider the crucial traits that combine information from many PCs and contribute to phenotypic diversity. Based on the findings of the aforementioned study, the genotypes such as PED, IIHR-2833, IIHR-2955, IIHR-2821, IIHR-Sel-57, IIHR-2327-1, IIHR-2273, IIHR-Sel-41-1, IIHR-Sel-19, IIHR-Sel-22, CLN3916C, CLN3916D, IIHR-2411-2 and IIHR-TLBER-7-4-11-34 were considered as best performers with good processing quality.

FUTURE SCOPE

The nutritional importance of the tomato indicates there is need to formulate breeding programme and develop cultivar suitable for processing traits with high quality of fruits as well as yield.

Acknowledgement. We are highly thankful to division of Vegetable Science, IIHR, Bengaluru and department of Vegetable Science, College of Horticulture, Bengaluru, University of Horticultural Sciences, Bagalkot, Karnataka for providing facilities for the smooth conduct of research work.
Conflict of interest. None.

REFERENCES

Adsule, P. G., Dan, A. and Tikko, S. K. (1980). Studies on the evaluation of tomato cultivars for making juice. *Indian Food Packer*, *34*, 18-20.

Anonymous (2022). *Indian Horticulture Database*, www.nhb.com, 127-135.

Anuradha, B., Saidaiah, P., Ravinder Reddy, K., Harikishan, S. and Geetha, A. (2020). Genetic variability, heritability and genetic advance for yield and yield attributes in tomato (*Solanum lycopersicum* L.). *Int. J. Curr. Microbiol. App. Sci*, *9(*11), 2385- 2391.

Aralikatti, O., Kanwar, H. S., Chatterjee, S., Patil, S. and Khanna, A. (2018). Genetic variability, heritability and genetic gain for yield and quality traits in tomato (*Solanum lycopersicum* L.). *Int. J. Chem. Stud.*, *6*(5), 3095-3098.

Balasubramanian, T. (1984). Studies on quality and nutritional aspects of tomato. *J. Food Sci. Technol*, *21*, 419-421.

Basavaraj, L. B., Vilas, D. G. and Vijayakumar, R. (2015). Study on genetic variability and character inter-relationship of quality and yield components in tomato (*Solanum Lycopersicon* L.). *HortFlora Research Spectrum*, *4*(2), 108-115.

Bhandari, H. R., Srivastava, K. and Eswar Reddy, G. (2017). Genetic variability, heritability and genetic advance for yield traits in tomato (*Solanum lycopersicum* L.). *Int. J. Curr. Microbiol*, *6(7)*, 4131-4138.

Burton, G. W. (1952). Quantitative Inheritance in Grasses. *Proc. 6th Int. Grassland Cong, 1*, 277-283.

Chernet, S., Belew, D. and Abay, F. (2014). Genetic diversity studies for quantitative traits of tomato genotypes in Western Tigray, Northern Ethiopia. *J. Plant Breed. Crop Sci*, *6*(9), 105-113.

Dutta, P., Hazari, S., Karak, C. and Talukdar, S. (2018). Study on genetic variability of different tomato (*Solanum lycopersicum* L.) cultivars grown under open field condition. *Int. J. Chem. Stud*, *6*(5), 1706-1709.

Ghosh, K. P., Islam A. K. M. A., Mian M. A. K. and Hossain M. M. (2009). Genetic diversity in F_2 segregating population of different commercial hybrids of tomato (*Solanum lycopersicum* L.), *Bangladesh J. PI. Breed Genet*, *22*(1), 43-48.

Hanson, C. H., H. F. Robinson and R. E. Comstock. (1956). Biometrical studies on yield in segregating population of Korean lespedesa. *Agron. J., 48*, 268-272.

Kaushal, A., Singh, A., Chittora, A., Nagar, l., Yadav, R. K. and Kumawat, M. K. (2017). Variability and correlation study in tomato (*Solanum lycopersicum* L.). *Int. J. Agric. Sci, 9*(29), 4391-4394.

Kavyashree, N., Revanappa, Sathish, D. and Gururaj, S. (2017). Variability and heritability studies in advanced tomato (*Solanum lycopersicum* L.) lines. *Environment and Ecology*, *35*(2C), 1309-1313.

Kumar, P., Bora, L., Batra, V. K. and Sheena, N. K. (2018). Genetic variability, heritability and genetic advance studies for yield and quality traits among diverse genotypes of tomato (*Lycopersicon esculentum* Mill). *Int. J. Curr. Microbiol. App. Sci*, *7*(9), 1391-1397.

Kumari, K., Akhtar, S., Kumari, S., Kumar, M., Kumari, K., Singh, N. K. and Ranjan, A. (2020). Genetic variability and heritability studies in diverse tomato genotypes. *J. Pharmacogn. Phytochem, 9*(3), 1011-1014.

Lewis, G. J. and Lisle, T. A. (1998). Towards better canola yield; a principal components analysis approach. In Proceed 9th Australian Conference. Wagga. School of Land and Food. The University of the Queensland. Lawea, Qld (4345).

Ligade, P. P., Bahadur, V., and Gudadinni, P. (2017). Study on genetic variability, heritability, genetic advance in tomato (*Solanum lycopersicum* L.). *Int. J. Curr. Microbiol. Appl. Sci*., *6*(11), 1775-1783.

Meena, O. P. and Bahadur, V. (2017). Principal component and cluster analysis of indigenous tomato genotypes based on morphological indicators. *Res. J. Biotech*, *12* (7), 50-58.

Meena, O. P. and Bahadur, V. (2014). Assessment of genetic variability, heritability and genetic advance among tomato (*Solanum lycopersicum* L.) germplasm. *The Bioscan*, *9*(2), 783-787.

Merk, H. L., Yames, S. C., Deynze, A. V., Tong, N., Menda, N., Mueller, L. A., Mutschler, M. A., Loewen, S. A., Myers, J. R. and Francis, D. M. (2012). Trait diversity and potential for selection indices based on variation among regionally adapted processing tomato germplasm, *J. Amer. Soc. Hort. Sci*, *137*(6), 427-437.

Panchbhaiya, A., Singh, D. K., Verma, P. and Mallesh, S. (2018). Assessment of genetic variability in tomato under polyhouse condition for fruit quality and biochemical traits. *Int. J. Chem. Stud*, *6*(6), 245-248.

Patel, P., Kumar, U., Maurya, P. K., Thakur, G. and Pramila (2017). Genetic variability studies in tomato (*Solanum* *lycopersicum* L.). *Bull. Env. Pharmacol. Life Sci.*, *6*(1), 216-218.

Prajapati, S., Tiwari, A, Kadwey, S. and Jamkar, T. (2015). Genetic variability, heritability and genetic advance in tomato (*Solanum lycopersicon* Mill.). *Int. J. Agric., Environ. Biotec.*, *8*(2), 245-251.

Rai, A. K., Vikram, A. and Pandav. A. (2016). Genetic variability studies in tomato (*Solanum lycopersicum* L.) for yield and quality traits. *Int. J. Agri. Environ Biotech*, *9*(5), 739-744.

Rawat, M., Singh, D. and Kathayat, K. (2020). Studies on genetic parameters for yield and yield attributing traits in tomato (*Solanum lycopersicum* L.). *J. Pharmacogn. Phytochem*, *9*(3), 1439-1442.

Shankar, A., Reddy, R. V. S. K., Sujatha, M. and Pratap. M. (2013). Genetic variability studies in F_1 generation of tomato (*Solanum lycopersicon* L.). *J. Agri. Vet. Sci.*, *4*(5), 31-34.

Sherpa, P., Pandiarana, N., Shende, V. D., Seth, T., Mukherjee, S. and Chattopadhyay, A. (2014). Estimation of genetic parameters and identification of selection indices in exotic tomato genotypes. *Electron J. Plant Breed.*, *5*(3), 552-562.

Sonam, S. and Sanjeev, K. (2017). Genetic divergence studies for quantitative and quality traits in tomato (*Solanum lycopersicum* L.). *Int. J. Environ. Agric. Biotech*, *2*(3), 1227-1231.

Sureshkumara, B., Lingaiah, H.B., Venugopalan, R. and Shivapriya, M. (2018). Genetic variability studies for yield and quality traits in tomato (*Solanum lycopersicum* L.). *Int. J. Pure App. Biosci*, *6*(4), 462-467.

Taiana, T., Rashid, M. H. U., Parveen, S., Hossain, M. S. and Haque, M. A. (2015). Selection strategies to choose better parents in tomato using genetic parameters. *Plant Knowledge Journal*, *4*(1), 33-39.

Takeoka, G. R., Dao, L., Flessa, S., Gillespie, D. M., Jewell, W. T. and Huebner, B. (2001). Processing effects on lycopene content and antioxidant activity of tomatoes. *J. Agri. Food Chem*, *49*, 3713-3717.

Thapa, B., Pandey, A. K., Agrawal, V. K., Kumar, N., and Mahato, S. K. (2016). Trait association studies for yield components in tomato (*Solanum lycopersicum* L.). *Int. J. Agric. Sci*, *8*(1), 934-937.

How to cite this article: Ramavath Ramesh Babu, Prasanna H.C., J.S. Aravinda Kumar, Jyothi Kattegoudar, Ranjitha K., S. Sriram, R.H. Laxman, K.V. Ravi Shankar and C.N. Hanchinamani (2023). Identification of Novel Genotypes Suitable for Processing in Tomato (*Solanum lycopersicum* L.) using Genetic variability Studies and Principal component Analysis. *Biological Forum – An International Journal*, *15*(9): 872-881.