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Genetic variability studies for yield and quality trait in tomato (*Solanum lycopersicum* L.)

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Abstract
The current study was carried out at the North Instructional farm of School of Agricultural Sciences, Karunya Institute of Technology and Sciences, Karunya Nagar, Coimbatore during 2020-23 to assess the yield and genetic variability of twenty seven genotypes of tomato (*Solanum lycopersicum* L.). The genotypes were collected from different parts of the country. The experiment was laid out in RBD with three replications. Based on the mean performance the genotype Kashi Aman was found to have high fruit yield per plant and also had reasonable level of ascorbic acid and lycopene content. The magnitude of phenotypic coefficient of variation was slightly higher that genotypic coefficient of variation for all the traits expect average fruit weight, seed number per fruit, number of locules. Further high estimate of heritability and genetic advance as percent of mean were recorded for average fruit weight, seed number per fruit, yield per plant, number of fruits per cluster, number of fruits per plant, number pf cluster per plant, plant height, seed weight per fruit, fruit breadth, 100 seed weight, fruit length, FSI, pericarp thickness, TSS, number of secondary branches and ascorbic acid content. High heritability and high genetic advance are always preferred for an effective selection and improvement.

Keywords: *Solanum lycopersicum* L., RBD, genotypic coefficient variation, phenotypic coefficient of variation, heritability and genetic advance as percent of mean

Introduction
Tomato is an important vegetable crop in India. It is an accepted vegetable at the global level. It is a protective food because it has special nutritive value and antioxidant properties Sepat *et al*. (2013) [18]. However, the production and productivity of tomato in India is far below the global average. Therefore, there is a need to develop superior varieties/hybrids that are better suited to the for different agro-ecological conditions. Collection and evaluation are the preliminary step in any breeding programme. The success of conventional breeding depends on the availability of desired genetic variability Ara *et al.* (2009) [2]. Genetic resources enable plant breeders to create novel gene combinations and select crop varieties more suited to the needs of diverse agricultural systems Glaszmann *et al.* (2010) [7]. Russian scientist Vavilov *et al.* (1951) [21] realised the significance of genetic variability, proposed that choosing a genotype with a desirable trait require a wide range of variability. The efficiency of selection depends on the nature and extent of genetic variability, degree of transmissibility of desirable characters and the actual expected genetic gain for the character in a population Golani *et al.* (2007) [8].
Therefore, it is important to study the genetic variability, heritability, and genetic gain among different genotypes of tomato for various horticultural traits. This information can be used to develop superior varieties/hybrids that are better suited to the needs of the Indian farmers and consumers.

Materials and Methods
The experimental material consisting of 27 genotypes of tomato collected from various sources (Table 1) were evaluated at the North Instructional Farm of Karunya Institute of Technology and Sciences which is located in the southern parts of the Western Ghats in the foothills of Siruvani forest, with the coordinate 10º 59'18.1662" N latitude, 76º 44' 22.2458" E longitude.
The experiment was laid out in Randomized Block Design (RBD) with three replications. Six weeks after sowing the healthy seedlings were transplanted to the main field in rows at a spacing of 60 cm between plants. The recommended cultural and management practice were given for the transplanted crop.

The observations were recorded for 21 characters *viz*., number of secondary branches per plant, days to first flowering, plant height (cm), days to first harvest number of clusters per fruit, number of fruits per cluster, Fruit length (mm), fruit width (mm), fruit scale index (FSI), number of fruits per plant, fruit yield per plant (g), 100 seed weight(g),
average fruit weight (g), seed weight per fruits (g), pericarp thickness (mm), number of locules per fruit, shelf life, total soluble solid (° Brix), lycopene content (mg/100 g). ascorbic acid (mg/100 g) in five randomly selected plants from each genotype in each replication. Phenotypic and genotypic coefficient of variation was estimated according to Burton and De Vane *et al.* (1953) [4]. Heritability in broad sense was calculated using the formula suggested by Lush (1940) [13]. Genetic advance and Genetic advance as percentage of mean estimated according to Johnson *et al.* (1955) [10].

Table 1: List of the 27 genotypes of tomato and sources

S. No.	Genotype	Source
1	Bangallcot	Bangalloct, Karnataka
2	Thripur-1	Kangeyam, Tamil nandu
3	Vettiyar palayam	Krishnarayapuram, Tamil nandu
4	Thingalur – 1	Thanjavur, Tamil nandu
5	Thingalur- 2	Thanjavur, Tamil nandu
6	Krishnapuram	Madurai, Tamil nandu
7	Muthur	Coimbatore, Tamil nandu
8	PKM 1	TNAU
9	Junnur	Junnar, Pune, Maharashtra
10	Thirupur 2	Dharmapuram, Tamil nandu
11	Pusa rubi	Ricca seeds and garden, pune
12	Kashi	Chatradi, Udupi, Karnataka
13	Mayanad	Mayanad, kollam, kerala
14	BLPM 1	Balaramapuram, Trivandrum
15	BLPM 2	Balaramapuram, Trivandrum
16	Kashi Adarsh	IIVR, Uttar Pradesh
17	Kashi Aman	IIVR, Uttar Pradesh
18	Yellow tomato local	Nanjangnd, Mysor, Karnataka
19	Kolar medium local	Kolar, Karnataka
20	Jayanth	Thrissur, kerala
21	Chitthur	Chitthur, Andhra Pradesh
22	Madanapalli	Madanapalle, Andhra Pradesh
23	Guntur medium local	Guntur, Andhra Pradesh
24	Mysore local 1	Gundulpet, Mysor. Karnataka
25	Kaziranga local	Barpeta, Assam
26	Mysore local 2	Gundulpet, Mysor. Karnataka
27	Thengani Kotai	Thengani Kotai, Karnataka

Results and Discussion

Mean performance of 27 genotypes of tomato (*Solanum lycopersicum* L.)

The mean performance of 27 genotypes in tomato presented in (Table 2) showed wide variation among the genotypes for different characters. Yield per plant is one of the important characters which showed a wide range from 279.3 to 3326 g/plant. The highest yield was shown by Kashi Aman, it was also found to be superior in number of secondary branches, number of clusters per plant, number of fruits per cluster, average fruit weight, and shelf life. Kaziranaga local had superiority on days to first flowering, plant height, and TSS. Thripur took minimum days to first harvest. While considering the lycopene content the genotype Thingalur 1 had the maximum. The five locules per fruit was observed in Vettiyar palayalm, Thingalur 2, Muthur, PKM 1, Mayanad, BLPM 1. The number of locules provide the characteristics shape to tomato fruits.

Genotypic and Phenotypic Coefficient of Variability

The perusal of the data presented in the (Table 3) indicated that phenotypic coefficient of variability was higher in magnitude than their corresponding genotypic coefficient of variability for all the characters expect average fruit weight, seed number per fruit, number of locules. High phenotypic and genotypic coefficient of variability were recorded for yield per plant (67.79% and 67.78) followed by average fruit weight (40.47% and 40.47%), seed number per fruit (34.86% and 34.86%), number of locules (33.83% and 33.83%), seed weight per fruit (33.89% and 33.73%), shelf life (34.46% and 32.02%).

Moderate coefficient of variability both at phenotypic and genotypic level were observed for number of fruits per plant (29.23% and 29.20%) followed by 100 seed weight (23.21% and 22.94%), number of fruits per cluster (20.53% and 20.52%), number of secondary branches (20.72% and 19.42%), ascorbic acid (20.72% and 19.42%) pericarp thickness (18.85% and 17.91%), plant height (18.55% and 16.92) and fruit length (16.28% and 16.05%). Similar results were reported by Ara *et al.* (2009) [2], Dar *et al.* (2011) [6], Buckseth *et al.* (2012) [3], Rahaman *et al.* (2012) [17], Manna and Paul *et al.* (2012) [14], Kumar *et al.* (2013) [11], Patel *et al.* (2013) [15], Chadha and Bhusan *et al.* (2013) [5], Sidhva *et al.* (2014) [20].

Table 2: Mean performance of 27 genotypes of tomato

Genotype	SB	DFF	PH	DFH	NCP	NFC	FL	FB	FSI	NF	AFW
Bangallcot	6.65	30.00	138.00	76.66	7.05	4.53	41.30	41.22	1.00	34.61	62.20
Thripur 1	6.29	27.00	132.00	72.66	6.94	4.46	34.52	43.62	0.79	33.60	57.60
Vettiyar palayalm	5.73	31.00	118.00	81.00	6.50	3.93	30.94	44.32	0.70	28.16	41.20
Thingalur 1	4.88	30.00	109.00	75.00	6.05	3.47	33.68	47.75	0.71	23.60	36.80
Thingalur 2	5.62	31.00	114.00	83.00	6.36	3.86	31.87	40.02	0.80	28.16	41.00
Krishnapuram	5.06	27.00	110.00	84.66	6.17	3.56	32.14	43.85	0.73	24.60	38.20
Muthur	4.62	30.00	108.00	90.00	5.92	3.36	33.00	43.28	0.76	22.53	36.60
PKM 1	4.31	27.00	93.00	76.33	5.26	2.81	32.25	42.54	0.76	17.40	24.00
Junnur	5.09	31.00	110.00	85.00	6.25	3.68	32.72	42.84	0.76	25.62	40.00
Thirupur 2	5.83	31.67	119.00	83.00	6.69	4.06	31.87	35.07	0.91	29.83	41.40
Pusa rubi	6.12	31.00	128.00	83.67	6.82	4.35	46.64	56.15	0.83	32.31	50.60
Kashi	4.34	32.30	101.00	89.00	5.36	2.95	29.25	34.67	0.84	18.42	24.00
Mayanad	5.93	30.67	120.00	84.66	6.71	4.16	32.11	43.04	0.75	30.57	46.60
BRPM 1	4.43	33.00	104.00	86.33	5.46	3.07	30.65	39.57	0.77	19.38	25.00
BRPM 2	4.35	30.67	106.00	89.00	5.53	3.13	30.63	32.02	0.96	19.92	30.00
Kashi Adarsh	6.83	33.30	147.00	82.66	7.26	4.73	41.02	44.71	0.92	37.01	67.80
Kashi Aman	7.27	32.67	154.00	82.00	7.45	4.95	43.70	45.79	0.95	39.47	84.20
Yellow tomato local	4.39	29.00	106.00	84.00	5.65	3.08	35.02	40.95	0.86	20.04	31.00
kolar medium local	4.03	30.67	87.00	81.67	5.05	2.64	31.09	35.10	0.89	16.77	22.60
Jayanth	4.49	29.33	108.00	85.00	5.76	3.18	29.42	35.82	0.82	20.98	33.00
Chitthur	3.96	33.33	86.00	92.00	4.95	2.58	31.12	36.81	0.85	15.29	21.00
Madanapalli	6.04	30.00	126.00	75.33	6.77	4.28	41.06	44.25	0.93	31.81	50.20
Guntur medium local	4.06	30.00	88.00	83.00	5.15	2.74	30.96	31.95	0.97	16.77	23.00
Mysore local 1	4.57	28.33	107.00	87.00	5.85	3.25	32.58	44.10	0.74	21.67	35.00
Kaziranaga local	6.90	26.33	156.00	82.33	7.33	4.83	37.18	38.16	0.97	38.09	68.00
Mysore local 2	3.82	30.00	86.00	85.67	4.86	2.44	30.10	31.02	0.97	14.60	19.20
Thengani kotai	6.71	29.00	143.00	83.00	7.18	4.63	51.45	43.83	1.17	35.86	65.40
MEAN	5.27	30.20	115.00	83.10	6.16	3.66	34.75	40.83	0.86	25.82	41.32
CD 5%	0.63	4.42	2.81	4.25	0.10	0.04	1.57	1.38	0.04	0.57	0.40
CD 1%	0.83	5.89	3.74	5.66	0.13	0.06	2.09	1.84	0.05	0.76	0.54

Genotype	Y	SWF	SNF	NL	PT	100 SW	SL	TSS	AA	LC
Bangallcot	2143	17.99	85	2	0.63	21.18	5.67	4	32.42	42.34
Thripur 1	1913	27.16	128	4	0.51	21.22	2.67	4	52.78	25.45
Vettiyar palayalm	1160	53.34	216	5	0.34	24.73	2.33	4.6	41.37	29.78
Thingalur 1	871.7	21.71	102	4	0.42	21.34	3.67	4.8	31.88	80.36
Thingalur 2	1112	27.21	136	5	0.42	20.01	4.33	3.8	38.51	43.6
Krishnapuram	936.6	35.66	115	4	0.42	30.89	3.67	4.3	38.04	37.75
Muthur	823.2	36.71	162	5	0.42	22.64	2.33	4	41.12	4.733
PKM 1	418.8	45.02	210	5	0.43	21.5	4.67	4	44.28	43.54
Junnur	1030	54.89	157	4	0.52	34.86	3.67	3.8	32.59	75.45
Thirupur 2	1235	31.59	139	4	0.34	22.76	3.67	4	44.39	40.61
Pusa rubi	1620	32.9	112	4	0.41	29.31	5.667	4.8	55.49	38.6
Kashi	483.3	29.1	103	3	0.36	28.29	5.333	4.6	32.56	35.49
Mayanad	1412	38.58	151	5	0.45	25.5	4.667	4	46.55	73.72
BRPM 1	483.3	46.52	187	5	0.43	24.91	5.667	4.3	44.39	55.53
BRPM 2	596.3	21.19	81.8	2	0.27	25.89	5.333	4	52.62	69.24
Kashi Adarsh	2512	40.18	89.4	4	0.54	44.96	6.667	4.8	58.62	68.19
Kashi Aman	3326	44.16	155	3	0.55	28.54	8.333	3.7	55.73	72.22
Yellow tomato local	622.6	29.98	111	2	0.54	26.96	4.667	4.7	35.48	1.493
kolar medium local	361.6	22.09	82	2	0.41	26.94	3.333	5	52.75	61.45
Jayanth	682.5	20.22	86.9	4	0.43	23.28	5.333	5.2	29.43	48.54
Chitthur	323.1	27.87	128	3	0.52	21.77	4.667	4.1	61.56	12.36
Madanapalli	1577	14.37	72.2	2	0.57	19.93	6.667	4.7	58.72	38.17
Guntur medium local	386.7	20.7	85.9	2	0.42	24.09	3.333	4.9	50.46	28.59
Mysore local 1	765.8	33.48	170	4	0.34	19.64	3.333	4.1	32.72	36.37
Kaziranaga local	2598	26.65	69.4	2	0.52	38.42	5.667	5.3	52.68	6.774
Mysore local 2	279.3	29.55	95.1	2	0.43	31.08	4	5	47.24	15.33
Thengani kotai	2338	18.45	51.7	2	0.53	35.68	8.333	4.3	45.03	58.24
MEAN	1186	31.38	122	3.444	0.45074	26.53	4.728	4.4	44.793	42.37
CD 5%	22.64	1.663	1.1	0	0.361	1.5397	0.987	0.2	0.5832	0
CD 1%	30.18	2.217	1.46	0	0.4811	2.0521	1.316	0.3	0.7773	0

SB- Number of secondary branches, DFF- Days to first flowering, PH- Plant height (cm), DFH- Days to first harvest, NCP-Number of clusters per plant, NFC- Number of fruits per cluster, FL- Fruit length (mm), FB-Fruit breadth (mm), NF- No of fruits per plant, FSI- Fruit scale index (mm), AFW- Average fruit weight (g), Y-Yield per plant (g),SWF Seed weight/fruit (g), SNF-Seed number/fruit, NL-Number of locules, PT-Pericarp thickness (mm), 100SW-100 Seed weight (g), SL-Shelf life, TSS- Total soluble solid (° Brix), AC- Ascorbic acid (mg/100 g), LC-Lycopene content (mg/100 g).

Heritability and Genetic gain as percent of mean

Heritability (broad sense) estimates ranged from (1.00%) to (99.98%) according to the (Table 3). High heritability estimates were recorded for average fruit weight and seed number per fruit (99.98%) followed by yield per plant (99.97%), number of fruits per cluster (99.88%), number of fruits per plant (99.79%), number of clusters per plant (99.38%), plant height (99.23%), seed weight per fruit (99.09%), fruit breath (97.68%), 100 seed weight (97.67%), fruit length (97.15%), FSI (97.15), pericarp thickness (93.16%), TSS (91.45%), number of secondary branches and ascorbic acid content (87.81%), shelf life (86.34%) and days to first flowering (73.86%).

Genetic advance as a percent of mean ranged from (1.99%) to (139.62%). Genetic advance mean as a percent of mean was high in yield per plant (139.62%) followed by lycopene content (98.52%), average fruit weight (83.36%), seed number per fruit (71.80%), number of locules (69.18%), number of fruit per plant (60.08%), 100 seed weight (46.70%), ascorbic acid (43.24%), number of fruit per cluster (42.24%), number of secondary branch (37.49%), pericarp thickness (35.61%), plant height (34.72%), fruit length (32.58%), fruit breadth (27.19%), number of cluster per plant (26.10%), FSI (25.74%), TSS (20.19%), while it was low for days to first harvest (9.28%), shelf life (2.90%) and days to first flowering (1.98%).

High heritability with high genetic advance as a percent of mean were observed for average fruit weight (99.98% and 83.36%), seed number per fruit (99.98% and 71.80%), yield per plant (99.97% and 139.62%), number of fruits per cluster (99.88% and 42.24%), number of fruits per plant (99.79% and 60.08%), number of cluster per plant (99.38% and 26.1%), plant height (99.23% and 34.72%), seed weight per fruit (99.09% and 69.18%), fruit breadth (97.68% and 27.19%), 100 seed weight (97.67% and 46.7%), fruit length (97.15% and 32.58%) and FSI (95.97% and 25.74%), pericarp thickness (93.16% and 35.61%), TSS (91.45% and 20.19%), ascorbic acid and number of secondary branches (87.81% and 37.49%). The results are in line with Ara *et al.* (2009) [2], Kumar *et al*. (2012) [12], Buckseth *et al.* (2012) [3], Rahaman *et al.* (2012) [17], Manna and Paul *et al.* (2012) [14], Kumar *et al.* (2013) [11], Patel *et al.* (2013) [15], Chadha and Bhusan *et al.* (2013) [5], Sidhva *et al.* (2014) [20] and Prajapati *et al.* (2015) [16].

Among various parameters of variability, high coefficient of variation (phenotypic and genotypic) was found for yield per plant, average fruit weight, seed number per fruit, number of locules, seed weight per fruit, shelf life The phenotypic coefficient of variation (PCV) was slightly higher than the genotypic coefficient of variation (GCV) for all the traits except average fruit weight, seed number per fruit, number of locules. The PCV measures the total variation in a trait, while the GCV measures the variation due to genetic factors. The small difference between the PCV and GCV suggests that environmental factors, such as weather and soil conditions, played a relatively small role in the variation of the traits studied. Further, high estimates of heritability and genetic advance as a percent of mean were recorded for average fruit weight, seed number per fruit, yield per plant, number of fruits per cluster, number of fruits per plant, number pf cluster per plant, plant height, seed weight per fruit, fruit breadth, 100 seed weight, fruit length, FSI, pericarp thickness, TSS, number of secondary branches, ascorbic acid, Thus, it can be concluded that direct selection for these traits may lead to a significant improvement in locating superior tomato genotypes.

Low heritability coupled with low genetic advance as a percent of mean observed in lycopene content and days to first flowering, high heritability with low genetic advance as percent of mean observed in shelf life and days to first harvest also low heritability with high genetic advance as percent of mean observed in number of locules, which shows these traits are under the control of non-additive gene action, so the improvement in the traits can be made by partitioning the genetic variance future and make selection for suitable types in the segregating generation.

Table 3: Estimation of GCV, PCV, ECV, Heritability and Genetic Advance as a percent of mean of 27 genotypes of tomato

Traits	GCV	PCV	ECV	H^2 %	GA(M)
SB	19.42	20.72	7.24	87.81	37.49
DFF	3.02	9.46	8.96	10.22	1.99
PH	16.92	16.98	1.49	99.23	34.72
DFH	5.24	6.10	3.12	73.86	9.28
NCP	12.71	12.75	9.28	99.38	26.10
NFC	20.52	20.53	0.70	99.88	42.24
FL	16.05	16.28	2.75	97.15	32.58
FB	13.36	13.51	2.06	97.68	27.19
FSI	12.76	13.02	2.48	95.97	25.74
NF	29.20	29.23	1.35	99.79	60.08
AFW	40.47	40.47	0.60	99.98	83.36
Y	67.78	67.79	1.17	99.97	139.62
SWF	33.73	33.89	3.23	99.09	69.18
SNF	34.86	34.86	0.55	99.98	71.80
NL	33.83	33.83	0.00	1.00	69.69
PT	17.91	18.55	4.85	93.16	35.61
100 SW	22.94	23.21	3.54	97.67	46.70
SL	32.02	34.46	12.73	86.34	2.90
TSS	10.25	10.72	3.13	91.45	20.19
AA	19.42	20.72	7.24	87.81	37.49
LC	3.02	9.46	8.96	10.22	1.99

Conclusion

A broad range of variability for several yield and quality para meters was found after analysis of 27 tomato genotypes.

Accordance with result it can be concluded that average fruit weight, seed number per fruit, yield per plant, number of fruits per cluster, number of fruits per plant, number pf cluster per plant, plant height, seed weight per fruit, fruit breadth, 100 seed weight, fruit length, FSI, pericarp thickness, TSS, number of secondary branches, ascorbic acid were the most important characters for direct selection may result in a significant improvement in the ability to recognise the best tomato genotypes.

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