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Study on genetic variability studies in tomato (*Solanum lycopersicum* L.)

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Abstract
The present investigation was conducted in randomized block design with 38 genotypes (including three checks) of tomato in three replications for thirteen traits. The objectives were to assess the genetic variability for fruit yield and yield contributing characters. Analysis of variance showed that the mean squares due to genotypes were significant for all the thirteen characters. The estimates of PCV were higher than GCV for all the traits. The magnitude of GCV and PCV was found highest in case of unmarketable fruit yield per plant followed by marketable fruit yield per plant, pericarp thickness, total fruit yield per plant, average fruit weight, locules per fruit and numbers of fruits per plant.

Keywords: Genetic, variability, tomato

Introduction
Tomato is universally treated as “Protective food” and considered as “Poor man’s Orange”. Tomato fruits are consumed raw or cooked. Tomato in massive quantities is used for the preparation of many processed items like soup, juice, ketchup, puree, paste and powder. Tomato (*Solanum lycopersicum* L., 2n=2X=24) is a member of the family Solanaceae and the genus Solanum. Tomato is a herbaceous, annual to perennial, prostrate and sexually propagated plant with perfect flowers. It has taproot and growth habit of the plant is determinate and indeterminate. Tomato production is very influenced by environmental factors like temperature, light, relative humidity and carbon dioxide level within the atmosphere. Optimum range of temperature for its record yield is 20 to 24 °C. Tomato is known for its outstanding nutritive value, which is given as; per 100g of edible part of tomato fruits contain 93.10g moisture, 3.60g carbohydrates, 1.90g protein, 0.10g fat, 0.60g minerals, 0.70g fibers, 320 I.U. vitamin C (Ascorbic acid). The total amino acid is 100-350 mg/100 g of fruit weight. Planning and execution of a breeding programme for the improvement of quantitative traits depends, to a great extent, upon magnitude of genetic variability. Genetic variability for yield and its component traits are essential in the base population for successful crop improvement (Allard, 1960) [3]. The crop improvement also depends upon the extent to which desirable traits are heritable. Heritable variation can effectively be studied in conjunction with genetic advance. High heritability alone is not enough to make efficient selection in segregation, unless the information is accompanied for substantial amount of genetic advance (Johnson *et al.* 1955) [6]. Further, information on genetic diversity is used to identify the promising diverse genotypes, which may be used in further breeding programme. Therefore, keeping in view the above facts in mind the present study has been conducted to obtain information on the extent of genetic variability among thirty-eight genotypes of tomato and to assess their utility in developing heterotic combinations for commercial use.

Material and Methods
The experiment was conducted at Main Experimental Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Ayodhya, Uttar Pradesh, India during Rabi 2019. The experimental material for study consisted of thirty-eight genotypes including three checks (Arka Vikas, Kashi Aman and DVRT-2). The experiment was conducted in Randomized Block Design with three replications. Each genotype consisted of two row spaced 60 cm apart with plant to plant spacing of 50 cm. Observation were recorded for thirteen different characters of tomato i.e. days to 50% flowering, plant height, locules per fruit, pericarp thickness (mm), polar diameter

of fruit (cm), equatorial diameter of fruit (cm), number of fruits per cluster, average fruit weight (g), number of fruits per plant, marketable fruit yield per plant, unmarketable fruit yield per plant, total fruit yield per plant and total soluble solids (°Brix).

The mean values of data were subjected to the analysis of variance as per the procedure described by Panse and Sukhatme (1987) [9]. The genotypic and phenotypic co-efficient of variation were calculated as per formulae given by Burton and De-Vane (1953) [5]. Heritability and genetic advance were according to Allard (1960) [3] and genetic gain was estimated as per the method given by Johnson *et al.*, (1955) [6].

Result and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized as under.

The analysis of variance revealed significant genotypic differences for all thirteen characters (Table 1). A wide range of variability was observed for different quantitative traits indicating the scope for selection of suitable initial breeding material for further improvement. The mean performance of different genotypes as given in Table 2. revealed a wide range of variability for all the traits under study *viz.*, Days to 50% flowering (38.65 to 50.56 days), plant height (45.33 to 92.33 cm), locules per fruit (2.65 to 6.16), pericarp thickness (1.95 to 5.77 mm), polar diameter of fruit (1.95 to 5.77 cm), equatorial diameter of fruit (4.67 to 8.68 cm), number of clusters per plant (2.57 to 4.97), average fruit weight (31.84 to 90.63 g), number of fruits per plant (11.48 to 23.96), marketable fruit yield per plant (423.99 to 1479.08 g), unmarketable fruit yield per plant (31.58 to 132.36 g), total fruit yield per plant (455.51 to 1611.44 g) and TSS (5.46 to 7.40 °Brix) which again revealed the existence of good deal of variability in the germplasm and offers the opportunity for improvement in yield and quality traits of tomato. Similar findings have been also reported by many workers Khuntia *et al.* (2019) [7], Prakash *et al.* (2019) [10] and Akhter *et al.* (2021) [2]. The analysis of components of variance (Table 3) revealed that the phenotypic coefficient of variation was greater than genotypic coefficient of variation for all the characters. High magnitude of phenotypic as well as genotypic coefficient of variation were observed in case of unmarketable fruit yield per plant (37.28 and 36.78%) followed by marketable fruit yield per plant (26.96 and 26.32%), pericarp thickness (26.41 and 25.99%), total fruit yield per plant (26.42 and 25.80%), average fruit weight (25.73 and 25.11%), locules per fruit (23.53 and 22.63%) and numbers of fruits per plant (20.45 and 19.34%). This indicates possibility of obtaining higher selection response in respect of these seven traits. The high estimates of PCV and GCV for most of the traits were also reported by Ahmad *et al.* (2016) [1], Lekshmi *et al.* (2017) [8] and Khuntia *et al.* (2019) [7]. The genotypic coefficient of variation does not offer full scope to estimate the variations that heritable and therefore, estimation of heritability becomes necessary. The estimates of heritability (broad sense) varied from (82.00% to 97.40%) for different traits under study (Table 3). Further, genetic gain (expressed as per cent of population mean) was ranged from 12.56% to 74.782% for different traits (Table 3). In the present study, high heritability (>75%) coupled with high genetic advance (>20%) in per cent of mean were recorded for unmarketable fruit yield per plant (97.40 and 74.78%), pericarp thickness (97.00 and 52.69%), total fruit yield per plant (95.40 and 51.92%) and average fruit weight (95.00 and 50.48%). Thus, those traits which exhibited high heritability in broad sense and high expected genetic advance as per cent of mean may be considered to be largely governed by additive gene action and therefore, could be effectively improved through selection. Such traits are less under the influence of environment. High heritability along with high genetic advance have also been reported for most of the yield and yield attributing traits by Sajjan *et al.* (2016) [11], Bhandari *et al.* (2017) [4] and Singh *et al.* (2020) [12].

Table 1: Analysis of variance (mean squares) for thirteen quantitative characters in tomato

S. No.	Traits / D. F.	Mean squares		
		Replicate	Treatments	Error
		2	37	74
1	Days to 50% Flowering	8.35	32.37**	5.83
2	Plant height	6.41	441.48**	12.73
3	Locules per fruit	0.05	3.60**	0.27
4	Pericarp thickness	0.28	3.32**	0.1
5	Polar diameter of fruit	0.04	2.15**	0.1
6	Equatorial diameter of fruit	0.01	2.39**	0.11
7	Number of fruits per cluster	0.03	1.22**	0.2
8	Average fruit weight	26.23	680.49**	32.49
9	Number of fruits per plant	23.07	35.26**	3.75
10	Marketable yield per plant	30831.39	189207.81**	14001.67
11	Unmarketable yield per plant	50.1	2078.57**	54.36
12	Total fruit yield per plant	73867.34	201470.26**	9363
13	TSS	0.01	0.68**	0.02

Table 2: Mean performance of 38 genotypes for thirteen characters in tomato

Genotypes / Characters	Days to 50% Flowering	Plant Height	Locules Per Fruit	Pericarp Thickness	Polar Diameter	Equatorial Diameter	Number of Fruits Per Cluster	Average fruit weight	Number of fruits per plant	Marketable Fruits yield Per Plant	Unmarketable Fruits yield Per Plant	Total Fruits Yield Per Plant	TSS
NDT-7-1	41.73	58.81	3.34	2.52	6.59	7.02	4.15	71.47	15.48	1041.23	45.87	1087.10	5.84
2012/TLCVRes.-7-1	44.13	64.53	2.73	4.70	6.38	6.30	3.63	50.76	17.21	873.74	31.58	905.32	5.88
NDT-2-3	44.06	63.48	5.15	2.78	5.72	6.66	4.77	40.76	20.55	748.14	70.03	818.17	6.62
NDT-3	44.04	56.44	3.69	3.59	5.39	6.31	4.17	52.10	16.26	800.43	74.75	875.18	6.55
2013/TODVAR-5	47.27	61.01	5.63	5.70	6.45	6.25	4.17	64.98	12.41	877.66	70.67	948.33	6.81
NDT-2-1-1	50.25	79.63	4.33	5.17	6.41	7.20	4.65	82.30	17.99	1378.71	63.66	1442.37	5.62
Utkal Kumari	44.84	61.80	3.88	4.84	6.92	7.90	4.44	86.74	12.90	1072.85	78.70	1151.55	6.59
2013/TODVAR-2-2-2	41.50	63.60	5.64	5.05	4.74	4.99	4.72	32.83	11.61	423.39	32.12	455.51	5.65
NDT-8	39.72	74.59	4.59	3.92	4.45	5.75	4.55	44.64	22.15	935.08	112.04	1047.12	6.38
2013/TODVAR-2-2-1-1	43.46	92.33	5.83	5.01	5.88	6.19	2.96	54.85	13.52	649.17	64.27	713.44	5.72
NDT-2-1	45.28	60.24	2.97	3.56	6.28	6.92	3.47	76.08	14.22	954.82	85.77	1040.58	5.73
NDT-5-1-2-1	42.89	65.78	3.95	4.34	4.04	5.62	4.20	31.84	23.03	679.58	66.15	745.73	5.51
NDT-5-1-2-2	46.92	53.37	4.73	2.46	6.20	5.98	3.62	47.74	13.91	668.49	55.94	724.43	6.57
NDT-5-3-1-1	43.15	74.00	2.84	3.64	6.12	5.39	3.35	50.04	14.02	622.92	45.15	668.07	6.05
2015/TODINDVAR-1	38.65	68.64	5.92	5.77	4.82	5.45	4.59	42.78	23.63	934.28	123.83	1058.11	6.40
S5XNDT-3-2-1-1-2	40.06	67.86	5.74	3.20	4.28	4.85	3.14	40.11	20.44	769.57	75.24	844.81	5.46
NDT-5-2	40.88	51.13	2.65	4.05	4.51	5.27	3.82	46.37	16.68	780.19	62.65	842.84	6.13
NDT-3-1-2	47.61	82.22	5.92	4.43	6.52	7.17	4.52	70.31	14.61	1042.88	81.90	1124.78	5.79
NDT-3-1-1	43.19	65.27	5.96	2.23	5.67	5.53	4.97	65.47	23.93	1479.08	132.36	1611.44	6.03
NDT-5-3-1-2	39.63	58.59	5.53	2.32	5.20	5.58	3.44	47.08	23.96	987.65	116.10	1103.75	5.58
WT-1-2	45.15	57.58	3.96	2.67	6.63	6.62	3.43	63.62	13.62	815.77	34.14	849.91	5.94
3535	40.69	57.17	4.86	4.91	7.65	8.68	2.85	90.63	17.27	1478.14	71.99	1550.13	6.72
WT	44.85	73.55	5.42	3.21	5.75	6.83	2.71	63.93	15.85	946.77	75.67	1022.43	6.89
S5XNDT-3-2-2-1	47.48	67.77	4.95	4.60	4.64	4.67	2.57	35.72	16.68	581.31	46.28	627.59	6.75
Babu Ram-3-1-1	38.65	45.53	2.79	1.95	4.91	5.29	3.83	46.27	17.66	586.70	66.39	1053.58	6.88
2013/TODVAR-1	43.66	67.59	3.65	3.31	5.04	6.72	3.08	57.02	17.49	997.84	44.42	1042.26	6.38
NDTH-11W-22-1-2-1	46.93	73.72	3.67	5.41	6.26	6.33	3.48	56.02	16.92	887.44	42.52	929.96	7.40
S5XNDT-3-2-1-1-1	44.14	61.28	4.01	5.60	5.58	5.48	3.24	54.26	17.03	913.49	34.62	948.11	6.30
NDTH-11W-8-2-1	50.56	86.90	5.57	4.10	6.34	7.01	4.49	68.95	14.88	990.25	35.22	1025.47	5.60
12345	42.67	81.93	4.88	4.59	5.15	5.72	3.57	54.63	16.55	822.91	82.54	905.46	6.12
NDTH-11W-22-1-1-2	44.51	89.24	5.85	5.27	6.69	7.23	4.69	77.47	19.51	1392.44	90.71	1483.14	5.66
WT-1-1	46.21	87.64	3.48	3.65	6.44	6.55	3.46	63.90	12.93	840.22	53.94	894.16	6.39
NDTH-11W-22-1-2-2	42.66	89.10	6.16	3.39	6.40	7.16	4.36	87.19	15.42	1315.29	120.59	1435.88	5.81
NDTH-11W-17-1-3	45.61	83.28	5.14	2.84	6.70	7.00	3.77	62.96	13.79	756.20	81.57	837.77	5.75
S5XNDT-3-2-1-1	47.48	89.56	4.84	4.19	5.72	7.38	3.97	69.55	16.49	1109.05	90.30	1199.36	6.07
DVRT-2 (C)	49.98	64.53	4.96	4.33	5.65	6.59	4.53	59.96	15.24	859.78	72.69	932.47	6.54
Kasi Aman (C)	49.32	67.79	5.97	4.07	6.10	5.87	3.86	58.56	11.48	588.15	64.98	653.14	5.81
Arka Vikas (C)	38.70	58.92	5.71	4.05	5.00	5.33	3.80	54.30	19.55	976.87	85.92	1062.80	6.36
Mean	44.17	69.12	4.65	3.98	5.77	6.28	3.87	58.53	16.76	909.96	70.61	991.11	6.17
Range Highest	50.56	92.33	6.16	5.77	7.65	8.68	4.97	90.63	23.96	1479.08	132.36	1611.44	7.40
Range Lowest	38.65	45.53	2.65	1.95	4.04	4.67	2.57	31.84	11.48	423.99	31.58	455.51	5.46
SE(d)	1.97	2.91	0.42	0.26	0.26	0.27	0.37	4.65	1.58	96.61	6.02	79.01	0.12
CV	5.47	5.16	11.19	8.10	5.43	5.18	11.43	9.74	11.55	13.00	10.44	9.76	2.41
CD @ 1%	5.21	7.70	1.12	0.68	0.68	0.72	0.97	12.30	4.18	255.35	15.91	208.81	0.31
CD @ 5%	3.92	5.80	0.84	0.51	0.51	0.54	0.73	9.26	3.15	192.26	11.98	157.22	0.23

Table 3: Estimates of range, grand mean, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense, genetic advance (Ga) and Ga (in per cent of mean) for thirteen characters in tomato germplasm

S. No.	Genetic parameters characters	Range		ECV	PCV	GCV	Heritability in broad sense (%) (h^2 bs)	Genetic advance 5%	Genetic advance in per cent of mean 5%
		Lowest	Highest						
1.	Days to 50% Flowering	38.65	50.56	5.47	7.44	6.73	82.00	5.55	12.56
2.	Plant Height	45.33	92.33	5.16	17.55	17.3	97.00	24.27	35.11
3.	Locules Per Fruit	2.65	6.16	11.19	23.53	22.63	93.00	2.09	44.83
4.	Pericarp Thickness	1.95	5.77	8.11	26.41	25.99	97.00	2.1	52.69
5.	Polar Diameter	4.04	7.65	5.43	14.66	14.32	95.00	1.66	28.82
6.	Equatorial Diameter	4.67	8.68	5.19	14.21	13.89	96.00	1.76	27.97
7.	Number of Fruits Per Cluster	2.57	4.97	11.43	16.47	15.09	84.00	1.1	28.48
8.	Average Fruit Weight	31.84	90.63	9.74	25.73	25.11	95.00	29.54	50.48
9.	Number of Fruits Per Plant	11.48	23.96	11.55	20.45	19.34	89.00	6.31	37.66
10.	Marketable Fruit Yield Per Plant	423.99	1479.08	10.09	26.96	26.32	95.00	484.23	52.94
11.	Unmarketable Fruit yield Per Plant	31.58	132.36	10.441	37.277	36.786	97.40	52.806	74.782
12.	Total fruit yield per plant	455.51	1611.44	9.781	26.411	25.8	95.40	511.53	51.919
13.	TSS	5.46	7.40	2.414	7.709	7.582	96.70	0.947	15.362

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