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RESEARCH ARTICLE

Genetic variability and heritability studies in tomato (*Lycopersicon esculentum* Mill.)

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SUMMARY

Thirty four genotypes of tomato were evaluated during *Rabi* season of 2006 - 2007 for genetic parameters *viz.,* variability, heritability and genetic advance. The estimates of PCV and GCV were high for fruit weight followed by fruit length and lowest for number of flowers per cluster and total acid (%). Moderate value (20-30%) of PCV and GCV were recorded for fruits per plant, while other characters displayed less than 20 per cent. Moderate to low estimates of PCV was recorded against plant height, primary branches per plant, fruits per plant and yield per plant. However, days to first flowering, flowers per cluster, fruits per plant, fruit yield and average fruit weight recorded lower GCV values compared to their respective PCV values. The estimates of PCV and GCV values were close for days to 50 per cent flowering, days to full flowering, number of primary and secondary branches, plant height of all the fruit and quality characters except average fruit weight. High heritability coupled with high genetic advance expressed in percentage of mean was observed for selection for primary and secondary branches, plant height, fruits per plant, fruit length, fruit diameter, and fruit weight indicating that these traits were mainly governed by additive gene action and responsive for further improvement of these traits.

Key Words **:** Genetic variability, Heritability, Genetic advance, Tomato

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Tomato, *Lycopersicon esculentum* Mill which belongs to the nightshade family, Solanaceae, the world's largest vegetable crop after potato and sweet potato and it tops the list of canned vegetables and occupies an area of 4.5 mha in the world with an annual production of 123.6 mt. The productivity of tomato in India is very low (15.60 t/ha) compared to the global average (25.09 t/ha). Low productivity of tomato in India is mainly due to cultivation of unimproved types or/and un adapted types, cultivation in low priority area, poor crop management, inadequate plant protection measures, and non-availability of well-adapted and high yielding varieties for various agro-climatic regions. The non-availability of superior genotypes and low efficiency in utilizing the existing variability in plant breeding programmes has resulted in low space of crop improvement. Therefore, an alternative would be to go for indirect selection considering correlated traits with high heritability. In the present investigation, germplasm lines have been obtained from different agro-climatic regions of India.

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MATERIALS AND METHODS

The base material for the experiment consisted of thirty four genotypes/lines of tomato collected from different sources. The list of genotypes used in the study is given in Table A.

The field experiment was conducted during the *Rabi* season on farmer's field, under the supervision of Institute of Agriculture, Palli Siksha Bhavan, Visva Bharati University.

Table A : Showing the list of experimental materials used in the study

Sr. No.	Genotype	Source	Sr. No.	Genotype	Source
1.	Arka Abha	College of Horticulture,	18.	RCMT –2	College of Horticulture,
2.	Arka Meghali	Pasighat, Arunachal	19.	Rohini	Pasighat, Arunachal Pradesh
3.	Arka Vikash	Pradesh	20.	Roma	
4.	BT - 1		21.	S – 15998	
5.	BT - 10		22.	Sel –22	
6.	BT -11		23.	Sel –7	
7.	Local-1		24.	Sel –8	
8.	Manikham		25.	Sel -9B	
9.	Manilima		26.	Solan Vajer	Dr.YSPUHF, Solan
10.	Manithoibi		27.	Utkal Urvashi	OUA and T, Bhubaneswar
11.	Megha tomato -2		28.	Ojas	Monsanto Co.
12.	P-120		29.	PKM –1	
13.	Pathar Kuchi		30.	Aruna	
14.	Pusa Gaurav	IARI, New Delhi	31.	Prolific F1 hybrid	
15.	Pusa ruby		32.	German spl.	Germany
16.	Pusa Sheetal		33.	Laxmi (NP-5005)	
17.	RCMT -1		34.	Cherry tomato	Local

The field is situated under sub-humid, sub-tropical belt of West Bengal. Thirty-four tomato genotypes were sown in seedbed during *Rabi* season on 2006 and 2007. The experiment was laid out according to Randomized Block Design (RBD) with three replications. Each genotype was planted in three rows of 5m length with a spacing of 75cm x 60cm. All recommended package of practices were followed during the crop season for raising a healthy crop. Five randomly selected plants from each plot per replication were scored for recording the observations. The data has been recorded in 50 per cent flowering, plant height (cm), number of primary branch per plant, number of secondary branches per plant, number of flowers per cluster, number of fruits per plant, average fruit weight (g), fruit yield per plant (g), fruit yield per picking per plant (g), fruit length (mm), fruit diameter (mm), fruit firmness, locules per fruit, pericarp thickness (mm), total soluble solids (TSS, ^{o}Brix), total acid content (per cent).

RESULTS AND DISCUSSION

The analysis of variance shows that the significant difference indicating sufficient variability exists among the accessions. The range of variation for number of fruits per plant was wider compared to flowering, plant height and branching characters (Table 1). The fruits per plant varied from 8.5 (Aruna) to 30.0 (RCMT-2). Higher number of fruits per plant was observed in Manikham (29.25), LOCAL-1(27.63), S-15998 (27.63) and Pusa Ruby (27.0). Number of fruits per

Table 1 : Showing the estimates of range, grand mean, PCV, GCV, heritability and genetic advance and % of mean according to plant characters in tomato

Character	Range		Grand mean	PCV (%)	GCV (%)	Heritability	Genetic advance	GA as % of mean
Days to first flowering	12.00	24.00	15.97	19.29	15.43	64.05	4.05	25.36
Days to 50% flowering	19.50	31.50	23.09	14.53	12.39	74.05	5.08	22.00
Days to full flowering	30.00	41.00	33.57	10.39	8.15	61.68	4.41	13.14
Primary branch	8.75	22.38	12.12	12.93	11.23	90.92	2.36	19.47
Secondary branch	14.50	37.50	20.73	19.14	18.18	93.52	7.02	33.86
Flower per cluster	4.50	13.50	5.95	13.39	8.42	40.00	0.62	10.42
Plant height (cm)	74.88	100.5	83.98	6.61	6.10	86.23	9.76	11.62
Fruits per plant	8.50	264.5	26.60	24.70	17.42	49.74	7.87	29.59
Fruit yield /plant /picking (g)	40.8	538.8	283.8	16.57	11.51	48.21	46.70	16.46
Fruit yield per plant (g)	203.8	2693.8	1414.9	18.90	12.49	43.64	240.4	16.99

plant is the function of number of flowers per plant which are successful in setting the fruit and number of flowers per plant itself is related to number flowers per cluster and number of clusters per plant.

The fruit yield per picking and per plant showed the highest range of variation among the traits studied. The fruit yield per picking varied from 40.8g in cherry tomato to 538.8 g in Ojas, The highest yield per plant was recorded in Ojas (2693.75g) followed by Arka Abha (2425.0g) and RCMT-2 (2331.25 g). Some of the other genotypes, which had high fruit yield, were Sel-8, Laxmi, Manilima, Prolific F_1 hybrid and RCMT-1. The lowest yield was observed in Cherry (203.75g).

The estimates of coefficient of variation revealed highest variability for fruits per plant followed by fruit yield per plant per picking and fruit yield per plant (>20%) while number of secondary branches per plant had lowest variability among flower and plant characters. Among fruit and quality characters almost all traits recorded coefficient of variation of less than 15 per cent. However, number of fruits per plant stands out with highest variability of 22.12 per cent coefficient of variation.

Considering the performance of the genotypes across characters studied, Ojas, Arka Abha RCMT-2, Sel-8, Laxmi and Manilima were promising considering fruit yield per picking, fruit yield per plant and earliness. Besides, Arka Abha, Ojas, Aruna and Manithoibi were having high average fruit weight. Similarly most of the genotypes, which were promising, were good in one or few characters. However, by considering all the characters, Ojas, Arka Abha, Laxmi, Manilima, RCMT-2 were promising. These genotypes should be evaluated again over seasons in this region to identify stable genotypes and suitable genotypes for different growing seasons.

The information on various genetic parameters such as variance components, heritability, and genetic advance aids plant breeders in the development of breeding schemes or choice of materials from the germplasm pool (Shahi and Singh, 1985). The success of genetic advance under selection depends on genetic variability, heritability, and selection intensity (Allard, 1960). High variability, heritability and selection intensity gives high genetic advance.

The heritability estimation used in conjunction with genetic advance provides better information for selecting the best individuals than the heritability alone (Johnson *et al.*, 1955). Because, it is not only the heritability but also the high genetic gain per generation, which matters for speedy crop improvement.

High to moderate estimates of heritability accompanied with high to moderate genetic advance for days to flowering, plant height, primary branches per plant, fruits per plant, fruit length, locules per fruit, pericarp thickness, fruit diameter and firmness indicted the predominance of additive gene action in the expression of these characters (Johnson *et al.,* 1955). Hence, selection for the above characters would be effective in bringing about genetic improvement in these germplasm lines.

In case of flower and plant characters, the phenotypic and genotypic variances were highest for fruit yield and lowest for number of flowers per cluster (Table 3). These characters also showed highest and lowest phenotypic values, with widest range in fruit yield and narrow range in flowers per cluster. The phenotypic coefficient of variation (PCV) ranged from 6.61 per cent in plant height to 24.70 per cent in fruits per plant, while same characters recorded GCV range of 6.10 per cent to 17.42 per cent (Table 2). Moderate value (20-30%) of phenotypic coefficient of variation was observed for fruits per plant, while other characters displayed less than 20 per cent. However, days to first flowering, number of secondary branches and fruit yield recorded PCV values close to 20 per cent. Moderate to low estimates of phenotypic coefficient of variation for plant height, primary branches per plant, fruits per plant and yield per plant have been documented earlier by Brar *et al.* (2000) and *Joshi et al.* (2004). The values of genotypic coefficient of variation were less than 20 per cent for all characters of this group. Low estimates of GCV per cent for TSS were earlier reported by Kumar and Tewari (1999). Similar results were also observed earlier by Phookan *et al.* (1998) and Brar *et al.* (2000). In case of fruit and quality traits, the highest phenotypic and genotypic variances were observed in average fruit weight followed by

Table 2 : Showing the estimates of range, variance, PCV, GCV, heritability and genetic advance and % of mean according to fruit characters in tomato

Characters	Range	Grand mean	Phenotypic variance		Genotypic variance	PCV (%)	GCV (%)	Herit-ability	Genetic advance	GA as % of mean
Locules per fruit	2.00	7.00	3.46	1.86	1.56	39.46	36.14	83.87	2.36	68.18
Pericarp thickness (mm)	1.32	8.72	5.84	1.70	1.50	22.31	20.96	88.24	2.37	40.56
Fruit length (mm)	13.73	72.94	47.00	137.10	116..80	24.91	22.99	85.19	20.55	43.72
Fruit diameter (mm)	12.99	70.54	50.30	90.22	82.87	18.88	18.10	91.85	17.97	35.73
TSS (°Brix)	5.70	6.50	6.11	0.05	0.04	3.66	3.27	80.00	0.37	6.03
Firmness	1.00	3.00	2.04	0.48	0.44	33.97	32.53	91.67	1.31	64.16
Total acid (%)	0.38	0.89	0.66	0.02	0.01	18.95	18.32	93.55	0.24	36.51
Average fruit weight (g)	9.41	155.27	78.24	991.09	675.24	40.24	33.21	68.13	44.18	56.48

fruit length, while it was lowest for total acid (%) closely followed by TSS in this group of traits. The phenotypic values also showed the wide and narrow range for the above characters. The phenotypic coefficient of variation (PCV) ranged from 3.66 per cent in TSS to 40.24 per cent in average fruit weight. TSS recorded lowest GCV also (3.27%), while, highest GCV was observed for number of locules per plant.

The estimates of phenotypic coefficient of variation and genotypic coefficient of variation were high (>30%) for locules per fruit, firmness, and average fruit weight, while it was moderate (20-30%) for pericarp thickness and fruit length. Fruit diameter, total acid (%), and TSS exhibited low PCV (<20%). Similar results have been reported earlier for fruit weight by Bharti *et al.* (2002) and Joshi *et al.* (2004).

The estimates of PCV and GCV values were close for days to 50 per cent flowering, days to full flowering, number of primary and secondary branches, plant height and all the fruit and quality characters except average fruit weight indicating little influence of environment and consequently greater role of genetic factors in the expression of these characters. However, days to first flowering, flowers per cluster, fruits per plant, fruit yield and average fruit weight recorded lower GCV values compared to their respective PCV values indicating that these characters are influenced to a greater extent by environment.

In our investigation, heritability in broad sense (Table 1) was very high for number of secondary branches (93.52%), number of primary branches (90.92%) and plant height (86.23%). Moderate heritability (>60%, to <75%) has been displayed by flowering related characters except number of flower per cluster, which had low heritability (40%). Besides, fruit yield per plant and number of fruits per plant, an important yield component, also recorded low heritability (<50%).The results are in agreement with Brar *et al.* (2000), Mohanty *et al.* (2003) and Ahmed *et al.* (2006).

In case of fruit and quality traits, the high estimates of heritability (>80%) were observed for all the fruit and quality traits (Table 3) except for average fruit weight, which recorded moderate heritability (68.13%). The highest heritability was recorded in total acid per cent (93.55) followed by fruit diameter and firmness. The results are in agreement with the findings of Kumar and Tewari (1999), and Singh and Cheema (2005). Besides, Singh *et al.* (2001) for locules per fruit and Das *et al.* (1998) for length and width of the fruit also recorded similar observations.

For the flower and plant characters the estimates of genetic advance (Table 2) was high for secondary branches while it was moderate for fruits per plant, days to first and 50 per cent flowering. However, it was very low for flower per cluster (10.42%). Moderate to low genetic advance was observed in fruit yield per plant, days to full flowering, primary branches, and plant height. The results are in agreement with the findings of Brar *et al.* (2000). Bharti *et al.* (2002) and Mohanty (2003) for fruits per plant and yield per plant.

In case of fruit and quality traits, a very high genetic advance (Table 2) as per cent of mean was observed for locules per fruit, firmness, and average fruit weight. The findings show close proximity with Singh *et al.* (2001), Bharti *et al.* (2002), and Kumar *et al.* (2002). The genetic advance was lowest in TSS (6.03%) while remaining characters had high genetic advance *viz.,* fruit length, pericarp thickness and fruit diameter. Singh *et al.* (2005) reported very high genetic advance for pericarp thickness, acidity, firmness, and TSS.

Conclusion :

High heritability coupled with high genetic advance expressed in percentage of mean was observed for selection

Table 3 : Showing the best genotypes and their quantitative performance

Genotype	Days to 50% flowering (days)	Plant height (cm)	Flower per cluster	Fruits per plant	Fruit yield per plant (g)	Average fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)	Locules per fruit	Pericarp thickness (mm)	Total Sol. Solids (^{0}Brix)	Total acid (%)
Ojas	19.50	89.13	5.38	17.25	2694	155.3	64.81	63.65	3.50	8.02	6.33	0.38
Arka Abha	21.00	85.75	6.00	21.88	2425	114.6	54.50	70.54	7.00	6.90	5.87	0.64
RCMT -2	24.50	89.88	5.75	30.00	2331	77.4	46.71	46.46	2.00	6.44	5.83	0.77
Sel -8	22.00	78.00	5.50	15.63	1888	124.7	55.47	64.90	5.00	7.89	6.47	0.64
Laxmi(NP-5005)	21.00	74.88	6.00	25.13	1831	73.8	45.83	54.68	3.17	6.43	6.13	0.86
Manilima	21.50	89.50	6.63	24.50	1806	74.0	43.48	55.24	3.17	6.68	5.87	0.77
Prolific F1 hybrid	22.50	81.88	5.63	19.88	1788	89.0	57.20	54.02	3.00	6.68	5.77	0.54
RCMT -1	22.00	80.50	5.13	17.75	1781	102.7	63.00	55.39	2.83	8.72	6.03	0.39
Megha tomato -2	21.00	85.88	6.50	17.50	1725	98.5	53.08	50.30	3.83	5.98	6.30	0.58
Manikham	21.00	90.50	6.00	29.25	1700	59.9	49.76	47.25	2.00	6.93	6.20	0.53
C.D. (P=0.05)	3.75	4.17	1.17	9.48	408.77	36.18	9.17	5.52	1.24	5.52	0.20	0.06
C.D. (P=0.01)	5.04	5.60	1.57	12.74	549.11	48.61	12.32	7.41	1.66	7.41	0.27	0.09

for primary and secondary branches, plant height, fruits per plant, fruit length, fruit diameter, and fruit weight indicating that these traits were mainly governed by additive gene action and responsive for further improvement of these traits. A perusal of the data and results from above experiment revealed that selection for primary and secondary branches, plant height, fruits per plant, fruit length, fruit diameter, and fruit weight, would be effective in improving fruit yield, whereas, selection for pericarp thickness, total acid content, firmness, locules per fruit as well as the fruit weight would be effective for improving the quality characteristics of tomato fruit. Out of thirty four genotypes the top performers identified in the present investigation, such as Ojas, Arka Abha, RCMT-2, Sel-8 *etc*., should be evaluated over seasons and years to evaluate their suitability and stability. Most of the genotypes, which were promising, were good in one or few characters. In other words, different genotypes are superior in one or few desirable traits. Hence, there is a scope for further improvement in these genotypes, by combination breeding.

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