

Extent of Genetic Variability for Quantitative Traits in Tomato (*Lycopersicon esculentum* Mill.)

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Abstract

Genetic studies were conducted for yield and physiological traits in F₂ generation involving six crosses. The parameters statistically analyzed were mean, range and variability for yield and physiological traits. A wide variability was observed for plant height, flowering duration, number of fruits per plant, single fruit weight, dry matter accumulation and fruit yield per plant in F₂ generation. Among the progenies of six crosses studied in F₂ generation high mean, variability as percent of mean was exhibited by the crosses Co 3 × Arka Meghali and Co 3 × CLN 1462 AG for plant height, flowering duration, number of fruits per plant, single fruit weight style elongation, chlorophyll stability index, dry matter accumulation and fruit yield per plant. Variability studies revealed that all the traits exhibited higher phenotypic coefficient of variation (PCV) than the genotypic coefficient of variation (GCV) indicating environmental influence on the expression of characters.

Key words : Phenotypic variance, Genotypic variance, Quantitative traits, Tomato.

Tomato (*Lycopersicon esculentum* Mill.) belongs to solanaceous family occupies the largest area among the vegetable crops in the world, next to potato. Low production of tomato in India is mainly due to low yield as compared to world productivity. In view of this, it is imperative to develop proper plant breeding strategy to step up the production of tomato in India. Heat and drought stress are two major factors influencing productivity and adaptability of many varieties in the tropical and subtropical regions. In the tropical plains where tomato is grown, temperature often rises above 34 C, which exceeds the optimum temperature for fruit set. In general the rise in night temperature (exceeding the temperature of 20 C) decreases fruit set and fruit size. Unfortunately, the minimum temperature of Tamil Nadu also, never falls below 20 C during summer months. Hence attempts have been made in recent past to evolve a variety with potentiality of high yield and also tolerance for heat. Based on these objectives parents of heat tolerants were selected in this study.

Irrespective of the breeding objectives, the prime requirement in any crop improvement program has to create variability in the given population, so as to exercise selection for identifying promising lines according to the requirement. When such variability existing in the population is inadequate, it can be artificially manifested by controlled hybridization method followed by selection in segregating generations. This method is highly rewarding because of the possible occurrence of the transgressive segregants in the segregating populations (1). The success of identifying desirable transgressive segregants depends upon the method of handling the segregating population especially in earlier generations like F₂. This calls for proper statistical tool to judge the *per se* performance of the crosses and also the variability present in a cross.

Methods

The present study on tomato (*Lycopersicon*

Table 1. Mean performance of parents involved in intervarietal crosses of tomato in F₂ generation.

Parents	Plant height (cm)	Flowering duration (days)	Number of fruits/plant	Number of primary branches/plant	Single fruit weight (g)	Style length (mm)	Chlorophyll stability index (per cent)	Root length (cm)	Root : shoot ratio	Dry matter accumulation (g)	Fruit yield per plant (kg)
P ₃ (CO 3)	54.89	56.60	35.32	13.99	35.12	6.42	67.00	11.45	0.35	48.38	1.17
P ₄ (Arka Meghali)	54.34	53.56	29.65	10.82	51.69	8.10	67.53	12.89	0.28	41.44	1.47
P ₃ (Paiyur 1)	49.96	54.67	32.45	11.61	34.84	6.44	73.95	14.70	0.37	38.45	1.08
P ₆ (CLN 1462 AG)	56.46	59.38	50.97	13.25	18.75	5.64	72.92	16.20	0.36	44.73	1.09
P ₈ (H 24)	50.35	53.98	31.96	13.79	33.11	6.77	69.69	15.50	0.28	39.86	1.12
Mean	53.23	55.63	36.07	12.69	34.70	6.67	70.21	14.14	0.32	42.57	1.18
SE	1.15	0.95	3.42	0.56	4.67	0.35	1.25	0.77	0.01	1.60	0.07

esculentum Mill.) was carried out at the Agricultural College and Research Institute, Madurai during 2005-2006 involving F₂ generation of six intervarietal crosses, with the aim to select the best crosses/families and promising progenies in each cross, for yield and physiological characters.

The experimental materials included were six crosses of F₂ viz., P₃ × P₄ (CO 3 × Arka Meghali), P₃ × P₆ (CO 3 × CLN 1462 AG), P₄ × P₆ (Arka Meghali × CLN 1462 AG), P₄ × P₅ (Arka Meghali × Paiyur 1), P₄ × P₈ (Arka Meghali × H 24), P₅ × P₈ (Paiyur 1 × H 24) involving five parents viz., P₃ (CO 3), P₄ (Arka Meghali), P₅ (Paiyur 1), P₆ (CLN 1462 AG) and P₈ (H 24). The selfed seeds of F₁ generation from the previous study conducted by Rahul Marik (2) were used for raising the F₂ progenies.

Study of F₂ Generation

The F₂ generation was raised during June-October, 2005. A total of 250 plants of each cross were maintained in all the six crosses. Forty plants in each of five parents involved in the above crosses were also maintained. The progenies were evaluated for eleven characters on single plant basis for yield and physiological contributions.

The selected F₂ progenies were selfed with an idea of forwarding them to the next generation. Care was taken to maintain a healthy crop by adopting all the recommended cultural practices. Observations

were recorded on single plant basis in F₂ populations on plant height, number of primary branches per plant, number of fruits per plant, single fruit weight, fruit yield per plant, flowering duration and physiological characters viz., style length, chlorophyll stability index, root length, dry matter accumulation, root/shoot ratio.

Results and Discussion

The results revealed that significant differences existed between the crosses due to wide variability. Hence, the experimental material offers excellent scope for further improvement through selection.

Mean and Variance in Parents and Crosses

High mean and variability estimates were considered as criterion to select the best progenies in the present study. The selection of desirable genotypes is done based on the mean performance. In the present study, the parent Arka Meghali (P₄) excelled among the parents (Table 1) and the cross III (P₄ × P₆) and cross I (P₃ × P₄) with in the cross combination in F₂ generation accomplished with high mean expression towards fruit yield per plant (Table 2).

In the frequency distribution of segregants elicits the configuration of phenotypic variability of the trait studied. All the biometrical (agronomical) traits

Table 2. Mean, range and variability estimates of six intervarietal crosses of tomato for plant height (cm) in F₂ generation.

	Crosses	Range	Mean	Pheno- typic variance	Geno- typic variance	PCV (per cent)	GCV (per cent)
Plant height (cm)	P ₃ × P ₄	46.29—88.89	69.46	201.75	187.09	20.44	19.69
	P ₃ × P ₆	42.16—55.01	49.11	21.28	16.61	9.39	8.3
	P ₄ × P ₆	51.5—83.9	68.04	81.19	79.06	13.24	13.06
	P ₄ × P ₅	45.2—58.4	52.58	13.21	10.57	6.91	6.18
	P ₄ × P ₈	44.2—55.6	51.3	13.91	12.32	7.27	6.84
	P ₅ × P ₈	44.3—53.8	49.61	9.99	8.22	6.37	5.77
Flowering duration (days)	P ₃ × P ₄	25.21—47.68	35.6	35.81	35.12	16.8	16.64
	P ₃ × P ₆	26.21—67.97	52.61	230.1	229.42	28.83	28.78
	P ₄ × P ₆	32.1—55.9	44.41	48.12	47.55	15.61	15.52
	P ₄ × P ₅	26.31—50.12	39.29	54.2	53.41	18.73	18.6
	P ₄ × P ₈	48.4—53.9	51.29	2.14	1.28	2.85	2.2
	P ₅ × P ₈	47.3—56.6	52.77	9.61	8.76	5.87	5.6
Number of fruits/ plant	P ₃ × P ₄	23.5—46.4	34.01	42.32	41.29	19.12	18.89
	P ₃ × P ₆	25.2—66.5	44.55	180.86	180.01	30.18	30.11
	P ₄ × P ₆	9.42—12.97	11.18	1.27	0.06	10.07	2.2
	P ₄ × P ₅	25.4—42.7	31.74	37.38	36.49	19.26	19.03
	P ₄ × P ₈	23.0—26.3	24.41	0.73	0.01	3.5	0.47
	P ₅ × P ₈	22.9—29.7	27.15	4.77	4.19	8.04	7.54
Number of primary branches/plant	P ₃ × P ₄	9.1—16.3	13.6	3.68	3.26	14.12	13.29
	P ₃ × P ₆	9.35—15.64	12.66	5.02	4.61	17.69	16.96
	P ₄ × P ₆	17.86—51.55	33.86	131.19	130.73	33.81	33.75
	P ₄ × P ₅	8.5—12.5	11.05	1.13	0.72	9.63	7.69
	P ₄ × P ₈	8.7—12.4	10.62	0.77	0.4	8.28	5.99
	P ₅ × P ₈	9.0—12.9	10.93	1.34	0.92	10.62	8.81
Single fruit weight (g)	P ₃ × P ₄	13.65—58.86	43.2	51.77	50.5	16.65	16.44
	P ₃ × P ₆	13.35—26.82	22.21	9.44	8.63	13.83	13.22
	P ₄ × P ₆	33.1—46.2	39.25	11.43	10.56	8.61	8.27
	P ₄ × P ₅	17.3—55.9	36.98	185.43	184.48	36.82	36.72
	P ₄ × P ₈	19.0—57.6	39.19	167.82	166.99	33.05	32.97
	P ₅ × P ₈	25.5—36.9	31.75	15.44	14.73	12.37	12.09
Fruit yield/plant (kg)	P ₃ × P ₄	0.68—4.68	1.52	0.29	0.27	35.45	34.71
	P ₃ × P ₆	0.66—1.77	1.32	0.12	0.1	26.15	24.35
	P ₄ × P ₆	1.04—2.7	1.8	0.17	0.14	23.18	21.17
	P ₄ × P ₅	0.61—1.5	1.12	0.068	0.063	23.3	22.44
	P ₄ × P ₈	0.6—2.38	1.36	0.199	0.195	32.65	32.32
	P ₅ × P ₈	0.59—1.19	0.89	0.033	0.024	20.46	17.47
Tomato for style length (mm)	P ₃ × P ₄	5.25—9.3	6.94	1.39	1.35	17.03	16.79
	P ₃ × P ₆	5.39—7.14	6.49	0.21	0.2	7.13	6.98
	P ₄ × P ₆	5.15—7.9	6.51	0.36	0.33	9.32	8.93
	P ₄ × P ₅	5.39—7.69	6.6	0.47	0.43	10.39	9.92
	P ₄ × P ₈	5.1—7.4	6.51	0.4	0.37	9.73	9.36
	P ₅ × P ₈	4.7—7.8	6.44	0.69	0.68	12.9	12.82
Chlorophyll stabi- lity index (per cent)	P ₃ × P ₄	63.2—78.7	71.35	17	16.32	5.77	5.66
	P ₃ × P ₆	61.12—73.59	66.8	19.99	19.4	6.69	6.59
	P ₄ × P ₆	61.42—69.99	64.81	7.98	6.81	4.36	4.02
	P ₄ × P ₅	61.18—66.28	63.55	2.5	1.89	2.48	2.16
	P ₄ × P ₈	61.09—71.5	67.01	8.91	8.27	4.45	4.29
	P ₅ × P ₈	61.07—76.31	67.51	29.04	28.34	7.98	7.88
Root length (cm)	P ₃ × P ₄	10.1—15.6	13	2.55	1.84	12.29	10.45
	P ₃ × P ₆	19.9—38.0	29.13	28.84	28.09	18.43	18.19
	P ₄ × P ₆	10.1—17.1	13.96	4.36	3.59	14.96	13.57
	P ₄ × P ₅	9.9—16.99	13.93	4.78	4.12	15.7	14.57
	P ₄ × P ₈	10.1—15.8	12.46	3.3	2.71	14.57	13.2

Table 2. Continued.

	Crosses	Range	Mean	Pheno- typic variance	Genotypic variance	PCV (per cent)	GCV (per cent)
Tomato for root/ shoot ratio	P ₅ × P ₈	11.38—17.78	14.47	4.18	3.75	14.13	13.39
	P ₃ × P ₄	0.17—0.22	0.2	0.00023	0.00015	7.55	6.26
	P ₃ × P ₆	0.17—0.27	0.22	0.00087	0.00076	13.18	12.34
	P ₄ × P ₆	0.16—0.26	0.2	0.00052	0.00042	11.09	9.91
	P ₄ × P ₅	0.19—0.29	0.24	0.00127	0.00121	14.69	14.34
	P ₄ × P ₈	0.16—1.96	0.2	0.01268	0.01261	56.18	56.03
Dry matter accumu- lation (g)	P ₅ × P ₈	0.17—0.35	0.23	0.0013	0.0012	15.57	15.22
	P ₃ × P ₄	31.0—50.0	37.51	28.11	27.43	14.13	13.96
	P ₃ × P ₆	29.2—49.9	38.62	39.09	38.46	16.18	16.05
	P ₄ × P ₆	25.4—33.6	29.42	5.99	5.35	8.31	7.86
	P ₄ × P ₅	25.3—37.7	31.48	20.74	19.7	14.46	14.09
	P ₄ × P ₈	25.4—37.1	31.45	17.3	16.07	13.22	12.74
	P ₅ × P ₈	25.4—46.5	37.18	61.82	61.28	21.14	21.05

including fruit yield varied continuously and normally. Flowering duration, root length, dry matter accumulation and fruit yield per plant exhibited high distribution in all the F₂ cross combinations. This may be due to the parents namely CLN 1462 AG (P₆) and Co 3 (P₃) for flowering duration; CLN 1462 AG (P₆), H 24 (P₈), Co 3 (P₃) and Arka Meghali (P₄) for root length; Co 3 (P₃) and CLN 1462 AG (P₆) for dry matter accumulation; and Arka Meghali (P₄) for fruit yield per plant. Most of the characters namely plant height, number of primary branches per plant, number of fruits per plant, root length and dry matter accumulation displayed continuous variation in the F₂ cross combination but the continuous variation was disrupted with higher frequency of low and medium number of segregants. The reason attributed to this distribution was that the involved parents namely Paiyur 1 (P₅), H 24 (P₈) and CLN 1462 AG (P₆) for plant height; Arka Meghali (P₄), Paiyur 1 (P₅), H 24 (P₈) and CLN 1462 AG (P₆) for flowering duration; Co 3 (P₃), Arka Meghali (P₄), Paiyur 1 (P₅), H 24 (P₈) and CLN 1462 AG (P₆) for number of fruits per plant; Arka Meghali (P₄), Paiyur 1 (P₅), H 24 (P₈) and Co 3 (P₃) for dry matter accumulation; Paiyur 1 (P₅), CLN 1462 AG (P₆), H 24 (P₈) and Arka Meghali (P₄) for fruit yield per plant had low and high values.

The availability of rich source of segregants lends scope to exercise desirable selection. However, the maintenance and ability of expression of a particular character in succeeding generation are

tested by efficient genetic selection. This is achieved by disuniting the observed variability due to heritable and non-heritable component, aided by the genetic parameter such as phenotypic coefficient of variance (PCV), genotypic coefficient of variance (GCV) and heritability estimates. Using of these genetic parameters for effective genetic selection was suggested by number of earlier workers (3—5).

High phenotypic coefficient of variation (PCV) obtained here for the trait studied also revealed close correspondence of high genotypic coefficient of variance (GCV). The results suggest that those traits were least affected by the environment and selected for those traits based on phenotype would be rewarding. This indicates wild genetic segregation in the F₂ generation of all the six cross combinations, owing to high genotypic coefficient variance (GCV) in cross I for plant height, cross II for flowering duration, cross II and cross IV for number of fruits per plant, cross III for number of primary branches per plant, cross IV and cross V for single fruit weight and cross VI for dry matter accumulation offer scope for selection than other traits. However, the attributes like plant height in cross VI, flowering duration, number of fruits per plant and number of primary branches per plant in cross V, single fruit weight and dry matter accumulation in cross III produced a comparatively low degree of variability as evident from the low genotypic coefficient of variance (GCV). The expression of low degree of variability was also noticed by

Rajesh Kumar (6), Vijaya Mohan et al. (7) and Kumar et al. (8).

Salient Findings and Conclusion

The maximum plant height was observed in the cross $P_3 \times P_4$ (Co 3 \times Arka Meghali). The cross $P_4 \times P_6$ (Arka Meghali \times CLN 1462 AG) recorded the highest number of primary branches per plant in F_2 generation. The progenies of the cross $P_5 \times P_8$ (Paiyur 1 \times H 24) recorded the highest flowering duration followed by the cross $P_3 \times P_6$ (Co 3 \times CLN 1462 AG) and $P_4 \times P_8$ (Arka Meghali \times H 24). Style length was highest in the cross $P_3 \times P_4$ and lowest was recorded in the cross $P_5 \times P_8$ (Paiyur 1 \times H 24). The progenies of $P_3 \times P_4$ (Co 3 \times Arka Meghali) registered the highest single fruit weight followed by the cross $P_4 \times P_6$ (Arka Meghali \times CLN 1462 AG). Maximum chlorophyll stability index were observed in the cross $P_3 \times P_4$ (Co 3 \times Arka Meghali). Among the six F_2 crosses studied, the cross $P_3 \times P_6$ (Co 3 \times CLN 1462 AG) and $P_3 \times P_4$ (Co 3 \times Arka Meghali) recorded the highest dry matter accumulation and number of fruits per plant. Among the six crosses, the cross $P_3 \times P_6$ (Co 3 \times CLN 1462 AG) registered highest root length in F_2 generation. The trait root/shoot ratio was the highest in the cross $P_4 \times P_5$ (Arka Meghali \times Paiyur 1) followed by the cross $P_5 \times P_8$ (Paiyur 1 \times H 24) and $P_3 \times P_6$ (Co 3 \times CLN 1462 AG). The cross $P_4 \times P_6$ (Co 3 \times CLN 1462 AG) showed the highest fruit yield per plant than other five crosses.

In F_2 generation most of the crosses showed the lowest GCV and PCV for plant height. The results indicate that the narrow PCV and GCV were least affected by environment. The highest GCV and PCV recorded for flowering duration in the cross $P_3 \times P_6$ (Co 3 \times CLN 1462 AG). Except the cross $P_4 \times P_8$ (Arka Meghali \times H 24) and $P_5 \times P_8$ (Paiyur 1 \times H 24) all the remaining crosses registered the moderate GCV and

PCV for flowering duration. GCV was moderate in the cross $P_3 \times P_4$ (Co 3 \times Arka Meghali) for number of primary branches per plant, number of fruits per plant, single fruit weight, style elongation, root length and dry matter accumulation. All the six crosses recorded lowest PCV and GCV for chlorophyll stability index. Whereas, for fruit yield per plant all the crosses registered highest GCV values except the cross $P_5 \times P_8$ (Paiyur 1 \times H 24). The GCV and PCV values for the trait root/shoot ratio was lowest in the cross $P_3 \times P_4$ (Co 3 \times Arka Meghali) and highest in the cross $P_4 \times P_8$ (Arka Meghali \times H 24).

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