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STUDIES ON GENETIC VARIABILITY AND CHARACTERS ASSOCIATION OF FRUIT QUALITY PARAMETERS IN TOMATO

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ABSTRACT : The genetic variability and characters association of different fruit quality parameters were studied in 15 tomato genotypes grown in a two year field experiments. High and moderate to high GCV and PCV were recorded for number of locules / fruit, fruit weight, total acid (%), number of fruits/plant, vitamin C (mg /100g), fruit yield /plant, fruit length and pericarp thickness. High and moderate to high heritability coupled with high and moderate to high genetic gain in number of locules/fruit, fruit weight, fruit length, number of fruits/plant, pericarp thickness, vitamin C (mg/100g) and total acid (%) indicated the predominance of additive gene action, and therefore, these are more reliable for effective selection. Correlation coefficient revealed that fruit yield per plant was positively and significantly correlated with pericarp thickness, fruit length, fruit weight and number of fruits/plant indicating relative importance of these characters for yield improvement. Significantly positive and negative associations among different fruit quality parameters were also observed in the present study. The path coefficient analysis revealed that number of locules /fruit, TSS, fruit length, number of fruits/plant, fruit weight, vitamin C content and pericarp thickness had positive direct effect on fruit yield, while fruit width and total acid content had strong negative effects on the fruit yield.

Keywords: *Tomato, path analysis, correlation, GCV, PCV, heritability.*

Among different vegetable crops, tomato is one of the most popular and widely grown in the world. India's share to the world's production is only 14%, while it is about 26% in case of China. In India, the productivity of tomato is very low (15.60 t/ha) compared to the average productivity (25.09 t/ha) of the world. To improve the productivity of tomato, the primary consideration should be to bring about genetic improvement of the crop and development of superior varieties by selection among and within the population through the use of scientific breeding programme based upon the available genetic variability. It is, therefore, essential to assess the quantum of genetic variability, nature of character association with respect to different characters, which would help plant breeders in planning a successful breeding programme. Besides some yield contribution traits, some fruit quality parameters also affect the yield. The present investigation was, therefore, undertaken with a view to assess the nature of variability, heritability and genetic advance, and to determine the nature of association of different fruit quality parameters on fruit itself and among themselves through correlation and path analysis.

MATERIALS AND METHODS

The experimental materials for present studies consisting 15 diverse genotypes of tomato, viz. Sel 12, Sioux, Roma, Pusa Ruby, Solan Gola, Solan Vajer, S15998, EC 110964, EC 12217, Utkal Urbasi, Utkal Pallavi, Utkal Kumari, Utkal Deepti, Elegant and S22 were sown at Horticulture Farm of Palli Siksha Bhavan (Institute of Agriculture), Visva-Bharati, Birbhum, West Bengal (23°29' N, 87° 42'E and 58.9 m asl) during two 'rabi' seasons. These genotypes were sown in seed-bed during the month of November, and the seedlings were transplanted in the main field 25 days after sowing. The experiments were arranged in a randomized complete block design with three replications. Standard agronomic practices were followed to raise the crop.

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Samples were collected during peak period at harvest at full ripe stage of maturity (at both the growing seasons). A composite sample of 10-15 fruits was taken from selected plants of all the three replications. Evaluation was done on the same day for various quality parameters, viz. pericarp thickness, fruit length, fruit width, fruit weight, number of locules per fruit and biochemical traits viz. total soluble solids (°Brix), total acid content (%), vitamin C content (mg/100g). TSS content of fruit juice was estimated with the help of a hand refractometer (ERMA) calibrated at 20°C. The data thus obtained were corrected for temperature correction from standard correction table and represented in °Brix (A.O.A.C., 1). Total acidity was determined by titrating the diluted fruit juice against 0.1 (N) NaOH solution using phenolphthalein as an indicator (A.O.A.C., 1). The data were represented in terms of percentage of citric acid. The 2, 6-dichlorophenal indophenols dye titration method was used to estimate the ascorbic acid content of the fruit juice (Ranganna, 27).

Data collected during the two growing seasons on these traits were pooled, and analysis of variance was done as suggested by Panse and Sukhatme (24). Variability was estimated following Burton and De Vane (6). Heritability and genetic advance were calculated according to Hanson *et al*. (12) and Johnson *et al.* (14), respectively. Correlations were undertaken as per the procedure suggested by Johnson *et al.* (14) and Al Jibouri *et al.* (2) along with path coefficient analysis by Dewey and Lu (8).

RESULTS AND DISACUSSION

The analysis of variance revealed that all the characters exhibited highly significant difference among the genotypes, which was evident from the higher range for all the characters (Table 1). The estimates of PCV and GCV values for all the characters under study were almost same indicating little influence of environment and consequently greater role of genetic factors influencing the expression of these characters.

The estimates of GCV and PCV respectively were high (>30%) for locules /fruit (42.13 and 43.19) followed by fruit weight (34.84 and 35.38); moderate (20-30%) for total acid per cent (28.82 and 29.9), fruits/plant (27.39 and 29.91), vitamin C content (mg/100g) (27.32 and 27.50), fruit yield/plant (26.71 and 27.13), fruit length (24.17 and 24.86) and pericarp thickness (20.06 and 21.06); and low (<20%) for fruit width (13.40 and 14.01) and TSS (°Brix) (7.16 and 7.82). Similar results of high, and moderate to high GCV and PCV for these characters were also observed earlier by Mohanty (19,20), Phookan *et al.* (25), Sahu and Mishra (29), Singh *et al.* (32), Das *et al.* (7), Brar *et al.* (5) and Joshi *et al.* (15). Low estimates of GCV and PCV for TSS were earlier reported by Kumar and Tewari (17).

The genotypic coefficient of variation does not offer full scope to estimate the variation that is heritable, and therefore, estimation of heritability becomes necessary. The magnitude of heritability ranged from 81.90% (pericarp thickness) to 98.70% (vitamin C content). The results observed in present investigation were in agreement with the findings of Kumar and Tewari (17), Singh (34) for vitamin C content; Das *et al.* (7), Singh *et al.* (31) and Singh *et al.* (32) for locules per fruit, fruit weight; Reddy and Reddy (28), Pujari *et al.* (26), Sahu and Mishra (29), Padmini and Vadivel (23), Phookan *et al.* (25), Bharti *et al.* (3) and Mohanty *et al.* (19,20) for fruit yield /plant, number of fruits/plant, fruit weight; Das *et al.* (7) for pericarp thickness, length and width of the fruit; Joshi *et al*. (15), and Kumar *et al.* (16) for TSS. However, moderate to low estimates of heritability for locules/fruit have been reported by Joshi *et al.* (15). High heritability suggested the major role of genetic constitution in the expression of characters, and such traits are considered to be dependable from breeding point of view. However, the estimates of heritability alone are not sufficient for predicting the effect of selection. According to Johnson *et al.* (14), heritability used in conjunction with genetic advance provides better information for selecting the best individuals than the heritability alone. The value of genetic advance as per cent of mean (genetic gain) ranged from 13.54 (TSS) to 84.86 (locules/fruit). High and moderate to high estimates of heritability accompanied with high and moderate to high genetic gain for locules/fruit, fruit weight, fruit length, fruits/plant, pericarp thickness, total acid (%), fruit yield/plant and vitamin C content indicated the predominance of additive gene action for the expression of these characters. Hence, selection for the above characters would be effective for improvement of yield in this population. A perusal of the Table 1, wherein the results of PCV, GCV, heritability and genetic advance have been furnished, revealed that selection for fruits/plant, fruit weight, fruit length would be effective for improvement of fruit yield, whereas, selection for pericarp thickness, total acid, vitamin C content, locules/fruit as well as the fruit weight would be effective for the quality improvement of the fruit.

An estimate of genotypic and phenotypic (genotypic and phenotypic) correlation coefficients

Table 1: Estimates of range, mean, genotypic and phenotypic coefficient of variability, heritability and genetic advance for different traits in tomato.

Characters	Grand mean	Range	Coefficient of variance (%)	Heritability	Genetic advance	Genetic advance as per cent of mean	
			GCV	PCV			
1. Fruits per plant	23.30	15.32-37.00	27.39	29.91	83.9	12.04	51.67
2. Fruit length	4.07	2.88-6.63	24.17	24.86	94.5	1.97	48.40
3. Fruit width	4.44	3.40-5.50	13.40	14.01	91.5	1.17	26.35
4. Fruit weight (g)	43.62	23.50-88.67	34.84	35.38	97.0	30.84	70.70
5. Locules per fruit	3.18	2.00-6.00	42.13	43.19	95.10	2.69	84.86
6. Pericarp thickness	0.51	0.37-0.70	19.06	21.06	81.9	0.18	35.29
7. T.S.S.	6.57	5.58-7.53	7.16	7.82	83.8	0.89	13.54
8. Vitamin C (mg/100g)	46.06	27.47-77.92	27.32	27.50	98.7	25.75	55.91
9. Total acid (%)	0.48	0.30-0.73	28.82	29.90	92.9	0.28	58.33
10. Fruit yield per plant	825.30	437.10-1285.00	26.71	27.13	97.0	447.23	54.19

correlation coefficient among different pairs of characters of tomato is presented in Table 2. An overview of the table revealed that, in general, the genotypic and phenotypic correlations showed similar trend but genotypic correlation were at higher magnitude than phenotypic correlation in most of the cases. Very close values of genotypic and phenotypic correlation were also observed between some characters combinations that might be due to reduction in error (environmental) variance to minor proportions as reported by Dewey and Lu (8). Highly significant and positive with fruit yield were found for pericarp thickness (0.618 and 0.556) followed by fruit length (0.564 and 0.533), fruit weight (0.455 and 0.436) and fruits/plant (0.252 and 0.245) indicating importance of these characters for yield improvement. In former studies with tomato, fruit length, fruit weight (Das *et al.* 7; Yadav and Singh,36; Padma *et al.* 22; Joshi *et al.* 15); pericarp thickness (Bhushana *et al.* 4; Kumar *et al.* 18; Joshi *et al.* 15) and fruits/plant (Dhankar *et al.* 9; Harer *et al.* 13; Singh *et al.* 33) exhibited strong positive correlations with fruit yield. In the present study, total acid was also highly and positively correlated with fruit yield/plant. Significant positive genotypic and phenotypic correlations were also observed for fruit length with fruit weight (0.263 and 0.253), pericarp thickness (0.631 and 0.532); fruit width with locules/fruit (0.518 and 0.461) and Vitamin C content (0.392 and 0.375); fruit weight with pericarp thickness (0.424 and 0.369); locules per fruit with TSS (0.476 and 0.435), vitamin C content (0.216 and 0.213) and total acid content (0.235 and 0.217); and TSS with vitamin C content (0.339 and 0.310).

Although reports on the nature of character association in these traits are scanty, Das *et al.* (7) reported positive correlation of fruit weight and number of locules per fruit with fruit width, while positive association between total acidity and number of locules /fruit were reported by Kumar *et al.* (16).

Fruit yield per plant was negative and significantly correlated with locules /fruit, TSS and vitamin C content at both genotypic and phenotypic levels (Table 2). The results are in agreement with Padma *et al.* (22) and Mohanty (20). Significant negative correlation at both the levels were observed for fruits/plant with fruit length, fruit width, fruit weight, locules/fruit and vitamin C content which are at par with the findings of Mohanty (19,20), Padma *et al.* (22), Joshi et al. (15) and Singh *et al.* (33). In the present study, negative and significant correlation at both the levels were also observed for fruit length with locules/fruit, TSS and vitamin C content; fruit width with TSS; fruit weight with locules/fruit, TSS and Vitamin C content; locules/fruit with pericarp thickness; TSS with pericarp thickness and total acid content; and vitamin C content with total acid content. Padma *et al.* (22) also reported negative association between fruit weight and TSS, while negative correlation between locules/fruit with pericarp thickness, and fruit weight with vitamin C content were reported by Kumar and Tewari (17), and Joshi *et al*. (15), respectively. However, reports on the nature of the other character association are scanty and so has not been cited here.

Although correlation studies are helpful in determining the components of yield but it does not provide a clear picture of nature and extent of contributions made by number of independent traits. Path coefficient analysis, however, provides a realistic basis for allocation of appropriate weightage to various attributes while designing a pragmatic breeding programme for improvement of yield. The path coefficient analysis revealed that number of locules/fruit, TSS, fruit length, fruits/plant, fruit weight, vitamin C content and pericarp thickness had positive direct effects, in that order, on fruit yield while fruit width and total acid content had strong negative direct effects. The results are in conformity with Moya *et al*. (21) , Domini and Moya (10), Vikram and Kohli (35), Yadav and Singh (36), Sharma and Verma (30), Bhushana *et al.* (4) Dhankar *et al.* (9), Mohanty (19,20), Padma *et al.* (22), Harer *et al.* (13), Kumar *et al.* (16), Joshi *et al.* (15) and Singh *et al.* (33). Regarding indirect effects, it was observed that fruit width exhibited positive indirect effects towards fruit yield mainly via number of locules/fruit, TSS and vitamin C content; total acid content via TSS and number of locules/fruit. The main effects of number of locules /fruit and vitamin C content were significantly negative and resulted mainly from the negative indirect effects *via* TSS, fruit width, fruit length and fruit weight, whereas, the main effects of vitamin C content was significantly negative as it resulted from the negative indirect effect via fruit length, fruit weight, TSS and fruit width. The main effects of fruit weight and pericarp thickness were significantly positive and resulted mainly from the direct effect of the characters as well as from the positive indirect effects via fruit length and TSS.

Similarly for the character like fruit length, the positive and significant correlation coefficient was due to direct effect of the character as well as indirect effect via TSS and fruit weight indicating selection of these traits would be rewarding.

Total acid content had negative direct effect,

Table 2: Genotypic and phenotypic correlation coefficients of different fruit quality traits in tomato.

Characters		Fruit length	Fruit width	Fruit weight	Locules per fruit	Pericarp thickness	TSS (°Brix)	Vitamin C (mg/100g)	Total acid (%)	Fruit yield per plant
Fruits per plant	G	-0.258**	-0.704**	-0.343**	-0.379**	0.077	0.084	-0.144	0.011	0.152
	P	-0.217*	-0.596**	-0.316**	-0.350**	0.082	0.097	-0.131	0.001	0.145
Fruit length	G		-0.081	0.263**	-0.251	0.631**	-0.212*	-0.463**	-0.013	0.564**
	P		-0.068	0.253**	-0.239**	0.532**	-0.186	-0.44*	-0.009	0.533**
Fruit width	G			0.107	0.518**	-0.092	-0.329**	0.392**	0.003	-0.093
	P			-0.093	0.461**	-0.096	-0.263**	0.375**	0.016	-0.078
Fruit weight	G				-0.229*	0.424**	-0.420**	-0.331**	-0.367**	0.455**
	P				-0.229*	0.369**	-0.393**	-0.329**	0.346**	0.436**
Locules per fruit	G					-0.490**	0.476**	0.216**	0.235*	-0.353**
	P					-0.421**	0.435**	0.213**	0.217*	0.342**
Pericarp thickness	G						-0.355**	-0.316**	0.006	0.618**
	P						-0.325**	-0.275**	0.046	0.556**
TSS (°Brix)	G							0.339**	-0.339**	-0.351**
	P							0.310**	-0.297**	-0.316**
Vitamin C (mg/100g)	G								-0.303**	-0.47**
	P								-0.287**	-0.460**
Total acid (%)	G									0.251**
	P									0.234*

*Significant at 5% level **Significant at 1% level.

Table 3: Genotypic path coefficient of different fruit characters on fruit yield in tomato**.**

Characters	**Fruits/ plant**	**Fruit length**	**Fruit width**	**Fruit weight**	**Locule s/ fruit**	**Peric arp thick ness**	**TSS (oBrix)**	**Vitam inC (mg/1 00g)**	**Total acid**	**Fruit yield /plant**
Fruits per plant	**0.605**	-0.159	0.327	-0.202	-0.324	0.012	-0.062	-0.043	-0.004	0.152
Fruit length	-0.156	**0.615**	0.038	0.154	-0.214	0.102	0.157	-0.137	0.004	0.564**
Fruit width	-0.426	-0.05	**-0.465**	0.063	0.442	-0.015	0.243	0.116	-0.001	-0.093
Fruit weight	-0.208	0.162	-0.05	**0.588**	-0.196	0.068	0.311	-0.098	-0.123	0.455**
Locules per fruit	-0.229	-0.155	-0.241	-0.135	**0.853**	-0.079	-0.352	0.064	-0.079	-0.353**
Pericarp thickness	0.047	0.388	-0.043	0.249	-0.418	**0.161**	0.263	-0.093	-0.022	0.618**
TSS (°Brix)	0.051	-0.131	0.153	-0.247	0.406	-0.057	**0.74**	0.1	0.113	-0.35 **
VitaminC (mg/100g)	0.087	-0.285	-0.183	-0.194	0.185	-0.051	-0.251	**0.295**	0.101	-0.47 **
Total acid (%)	0.007	-0.008	-0.001	0.216	0.201	0.011	0.25	-0.089	**-0.334**	0.251**

Residual = 0.315   * Significant at 5% level   ** Significant at 1% level   Diagonal values (Bold) indicate direct effects

but high positive indirect effects through fruit weight, TSS and number of locules /fruit caused positively significant correlation. So, for the characters like fruit width and total acid, the indirect causal factors (mentioned above) are to be considered simultaneously for selection, since indirect effects seem to be the cause of correlation.

From the foregoing results it can be said that characters showing high heritability combined with high genetic advance e.g. fruit weight, fruits/plant, fruit length, locules/fruit, pericarp thickness and vitamin C content could be exploited for improvement thorough selection. In the present study, the characters like number of fruits/plant, fruit length, fruit weight, pericarp thickness, had appreciable direct effects towards fruit yield and proved as important components of fruit yield. The selection based on these characters may result in development of high yielding genotypes.

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