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GENETIC VARIABILITY AND CHARACTER ASSOCIATION FOR YIELD AND QUALITY TRAITS IN TOMATO (*Lycopersicon esculentum* Mill)

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ABSTRACT

The present investigation was conducted at Vegetable Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, during winter 2010. The experimental material comprised of thirteen genotypes and their thirty crosses along with two checks of tomato and the experiment was laid out in Randomized Block Design with three replications. Character association and genetic component of variation for ten yield and yield attributing characters as well as four quality traits of tomato were studied. The maximum genotypic and phenotypic coefficient of variation was (166.52 and 174.30) for plant height and minimum for Titratable acidity (0.02 and 0.03), respectively. Analysis of coefficient of variation revealed that magnitude of phenotypic coefficient was higher than genotypic coefficient of variation for all the yield and quality characters. The magnitude of genotypic and phenotypic coefficient of variation was higher for pericarp thickness (20.58 and 20.94), respectively. High values of heritability (broad sense) for pericarp thickness (97%) and high genetic advance were observed for plant height (25.68%). A positive and significant association of yield per plant with the plant height (0.32 and 0.30), primary branches per plant (0.67 and 0.47), number of fruits per plant (0.80 and 0.75), average fruit weight (0.56 and 0.50) and fruit shape index (0.60 and 0.55) whereas, days to 50% flowering (-0.38 and -0.34) negative significant correlated with yield per plant both at genotypic and phenotypic level as well as ascorbic acid positively significant correlated with titratable acidity (0.46 and 0.38) and lycopene (0.63 and 0.53), respectively.

***Keywords*:** Heritability, coefficient of variation, genetic advance, tomato, correlation

Tomato (*Lycopersicon esculentum* Mill) is the most widely grown vegetable crop in India. India is the second largest tomato producer in the world after China, accounting for about 11% of the world tomato production (FAOSTAT, 2013). The area and production of tomato in India was about 0.88 million hectare and 17.87 million tones, respectively with average productivity of 20.3 tonnes/ hecatre (National Horticulture Board, 2013).The state with higher production is Andhra Pradesh with a share of 32.25% and Uttar Pradesh having a share of 1.42%. Efforts are being made to increase its productivity by developing superior varieties. It is a nutritious and delicious vegetable used in salad, soups and processes into stable products like ketchup, sauce, pickles paste, chutney and juice. Lycopene in tomato is a powerful antioxidant and reduces the risk of prostate cancer (Hossain *et al*., 2004). Tomato is an important source of vitamin A, B, C and other nutrient element. Increased lycopene has proven nutritional value as an antioxidant that is associated with a low incidence of certain forms of human cancer (Bai and Lindhot, 2007).

The concept of heritability is important to determine whether the phenotypic difference found among different individuals are new to difference in their genetic makeup or simply a result of environmental factors. The yield being an important complex character is influenced by a number of its component characters. The genetic improvement of the crop depends largely upon the nature and relative magnitude of components of genetic variance involved for yield, quality and its components. Efforts are being made to increase its productivity by developing superior varieties. The ratio between genotypic and phenotypic coefficient of variation (GCV/PCV) of all the traits showed near to unity indicating the role of environment factor in the expression of traits would be negligible which elucidated that they could be improved to a large extent through selection. The heritability estimates are the better indicators of heritable proportion of variation. The high heritability indicates the effectiveness of selection based on phenotypic but, does not necessarily mean a high genetic gain for a particular character. Hence, consideration of both, heritability and genetic advance is more important for predicting effective selection than heritability alone. Johnson et al. (1955) reported that heritability estimates along with genetic advance would be more rewarding than heritability alone in

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predicting the consequential effect of selection to choose the best individual. The degree of association between characters as indicated by the correlation coefficients has always been a helpful instrument for the selection of desirable characters under a breeding program. Therefore, it is essential to make a comparative study among important characters to select desirable ones. With this information, the present investigation was carried out with objective to estimate the genetic component of variation, heritability, genetic advance and trait association among yield and yield traits as well as among quality parameters.

MATERIALS AND METHODS

The present investigations were conducted during winter- 2010 at Vegetable Research Farm, Institute of Agricultural Sciences, Banaras Hindu University Varanasi, which is situated at 25° North latitude, 83° East longitude at a mean altitude of 80.71 meters above the sea level, receiving annual rainfall of 1100 mm and sandy loam type soil.

Experimental material

The experimental material comprised ten genetically divers lines (H-24, DT-2, CO-3, Punjab Upma, Pant T-3, H-86, Selection-7, NDTVR-60, Fla-7171 and Kashi Amrit) and three testers (Floradade, Kashi Sharad and Azad T-5) along with their 30 F_1 hybrids developed by crossing them in a line X tester fashion. All the 43 genotypes (13 parents and 30 F_1 hybrids) with two checks were transplanted in a randomized block design with three replications at the spacing of 60 cm between rows and 45 cm between plants. Recommended cultural practices and plant protection measures were followed. The observation were recorded for eleven traits i.e. plant height, day to 50% flowering, number of primary branches, number of fruits per plant, average fruit weight, fruit per cluster, total yield per plant, TSS, ascorbic acid, titratable acidity and lycopene. Average data was statistically analyzed separately for the design of experiments as per Panse and Sukhatme (1978). Genotypic and phenotypic coefficient of variances was calculated according to Burton and De Vane (1953). Heritability and genetic advance were calculated according to Hanson *et al.* (1956) and Johnson et al. (1955), respectively. Genotypic and phenotypic correlations were computed using the formula of Al-Jibouri et al. (1958).

RESULTS AND DISCUSSION

Estimates of different genetic parameters are presented in Table-1. Results showed that the phenotypic variance is greater than genotypic variance and highest genotypic and phenotypic variance was observed for plant height (166.52 and 174.30) followed by average fruit weight (32.99 and 41.91), days to 50% flowering (19.04 and 20.80), number of fruits per plant (13.50 and 18.16), ascorbic acid (4.92 and 7.31.40), primary branches per plant (1.60 and 2.88), lycopene content (1.32 and1.82), pericarp thickness (4.97 and 1.04), fruit diameter (0.52 and 0.54), fruits per cluster (0.42 and 0.51), total soluble solids (0.33 and 0.40), yield per plant (0.31 and 0.33) and the lowest genotypic and phenotypic variance was that titratable ability (0.02 and 0.03), respectively.

Highest genotypic and phenotypic coefficient of variation was for pericarp thickness (20.58 and 20.94) followed by lycopene (19.62 and 23.16), fruit shape index (15.97 and 16.26), total yield per plant (15.80 and 16.25) fruits per cluster (14.20 and 15.61), days to 50% flowering (13.38 and 13.99), fruit diameter (13.29 and 13.60), primary branches per plant (13.13 and 17.62), plant height (12.76 and13.05), titratable acidity (9.97 and 12.66), total soluble solids (9.84 and10.88), number of fruits per plant (8.86 and 10.88), ascorbic acid (8.46 and 10.28) and the lowest genotypic and phenotypic variance was that average fruit weight (6.23 and 7.02) respectively. Genotypic coefficient of variation, which is the true indicator of the extent of genetic variability in a population, was the high for all the characters. Generally, higher PCV values than GCV were obtained for all tested traits.

The highest heritability was recorded on pericarp thickness (97%) with genetic advance and expected genetic advance over percentage of mean of (2.07 and 41.67%), followed by fruit shape index, and plant height (96%) with genetic advance and an expected genetic advance over percentage of mean of (0.35 and 32.30) and (25.98 and 25.68) followed by fruit diameter and total yield per plant with genetic and an expected genetic advance over percentage of mean of (1.45 and 26.74%), (1.12 and 31.65) and (55.81 and 3164) respectively. Days to 50% flowering (92%) with genetic advance and an expected genetic advance over percentage of mean of (8.60 and 26.38%), fruits per cluster (83%) with genetic advance and an expected genetic advance over percentage of mean of (1.22 and 26.63%), total soluble solids (82%) with genetic advance and an expected genetic advance over percentage of mean of (1.06 and 18.31%), average fruit weight (79%) with genetic advance and an expected genetic advance over percentage of mean of 10.50 and11.39%, number of fruits per plant (74%) with genetic advance and an expected genetic advance over percentage of mean of 6.53 and 15.74%, lycopene (72%) with genetic advance and an expected genetic advance over percentage of mean of 2.01 and 34.24%, ascorbic acid (67%) with genetic advance and an expected genetic advance over percentage of mean of 3.75 and 14.29%, titratable acidity (62%) with genetic advance and an expected genetic advance over percentage of mean of 0.09 and 16.17%, while the lowest heritability was that of number of primary branches per plant (56%) with genetic advance and an expected genetic advance over percentage of mean of (1.94 and 20.16%). The present result endured Mohanty (2003), Singh (2005), Singh *et. al.* (2007), Golani *et. al.* (2007), Haydar *et al.* (2007), Hidayatullah *et al.* (2008), Sharma *et al.* (2009), Kaushik *et al* (2011) and Dar and Sharma (2011).

The relationship between the characters in the hybrids depends upon the association existing in the parents. The genotypic and phenotypic correlation coefficients estimated between yield and inter-correlation among the different yield components are furnished in and only significant correlations are discussed here. In general, the magnitude of genotypic correlation coefficient was higher than the corresponding phenotypic coefficient indicating thereby a strong inherent association between various traits under study (Table-2).

In the present investigation plant height exhibited positive and significant correlation with number of primary branches per plant (0.48 and 0.33), number of fruits per plant (0.40 and 0.35), average fruit weight (0.29 and 0.24), fruit diameter (0.32 and 0.31), fruit shape index (0.28 and 0.27), fruits per cluster (0.46 and 0.43), total yield per plant (0.32 and 0.30) and pericarp thickness (29 and 28), while negative association was noticed with only days to 50% flowering (-0.30 and -0.29) at genotypic and phenotypic level, respectively.

Days to 50% flowering was found to be positive and significantly correlated with fruit diameter (0.24 and 0.22) at genotypic and phenotypic level, respectively and significant negative association with no. of fruits per plant (-0.25 and -0.20), fruit shape index (-0.22 and -0.20), total yield per plant (-0.38 and -0.34) and yield per plot (-0.39 and -0. 34) at genotypic and phenotypic level, respectively. Primary branches per plant exhibited positive and significant correlation with number of fruits per plant (0.63 and 0.46), average fruit weight (0.61 and 0.34), fruit diameter (0.35 and 0.20), fruit shape index (0.45 and 0.33), fruits per cluster (0.79 and 0.50) and total yield per plant (0.60 and 0.47) at genotypic and phenotypic level, respectively.

Number of fruits per plant was found to be positive and significant correlation with average fruit weight (0.66 and 0.45), fruit diameter (0.23 and 0.18), fruit shape index (0.57 and 0.49), fruits per cluster (0.58 and 0.42), total yield per plant (0.85 and 0.75) and pericarp thickness (0.22 and 0.18) at genotypic and phenotypic level, respectively. Average fruit weight was found to be positive and significant correlation with fruit diameter (0.41 and 0.37), fruit shape index (0.45 and 0.40), fruits per cluster (0.50 and 0.45), total yield per plant (0.56 and 0.50), and pericarp thickness (0.23 and 0.21) at genotypic and phenotypic level, respectively. Fruit diameter exhibited positive and significant correlation with fruit shape index (0.37 and 0.35), fruits per cluster (0.25 and 0.25) and pericarp thickness (0.27 and 0.25) at genotypic and phenotypic level, respectively. Fruit shape index exhibited positive and significant correlation with fruits per cluster (0.50 and 0.46), total yield per plant (0.60 and 0.55) and pericarp thickness (0.25 and 0.24). Fruits per cluster positively significant correlated with pericarp thickness (0.25 and 0.21) at genotypic and phenotypic level respectively.

Total yield per plant exhibited positive and significant correlation with plant height (0.32 and 0.30), primary branches per plant (0.60 and 0.47), number of fruits per plant (0.85 and 0.75), average fruits weight (0.56 and 0.50) and fruit shape index (0.60 and 0.55), while negative significant correlation with days to 50% flowering (-0.33 and -0.26) at genotypic and phenotypic level respectively.

On the basis of the value of phenotypic correlation coefficient depicted for all the ten character, fruit yield per plant exhibited high positive correlation with number of primary branches, number of fruits per plant and average fruit weight at both phenotypic and genotypic levels. This suggests that fruit yield can be increased whenever there is an increase in characters that showed positive and significant association with yield per plant. Hence these characters can be considered as criteria for selection for higher yield as these are mutually and directly associated with fruit yield. Similar type of

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Table-1: Summary of genetic parameters of 14 quantitative and qualitative characters in tomato

Characters	Mean	Variance		Coefficient of variation		Heritability (%)	Genetic Advance	
		Genotypic	Phenotypic	Genotypic	Phenotypic	Broad sense	GA (5%)	As 5% of mean
Plant Height (cm)	101.16	166.52	174.30	12.76	13.05	96	25.68	25.98
Days to 50% Flowering	32.60	19.04	20.80	13.38	13.99	92	8.60	26.38
Primary Branches Per Plant	9.63	1.60	2.88	13.13	17.62	56	1.94	20.16
No. of Fruits Per Plant	41.47	13.50	18.16	8.86	10.28	74	6.53	15.74
Average Fruit Weight (gm)	92.17	32.99	41.91	6.23	7.02	79	10.50	11.39
Fruit diameter	5.40	0.52	0.54	13.29	13.60	95	1.45	26.74
Fruit shape index	1.07	0.03	0.03	15.97	16.26	96	0.35	32.30
Fruits Per Cluster	4.58	0.42	0.51	14.20	15.61	83	1.22	26.63
Total Yield Per Plant (kg)	3.53	0.31	0.33	15.80	16.25	95	1.12	31.65
Pericarp Thickness (mm)	4.97	1.04	1.08	20.58	20.94	97	2.07	41.67
Total Soluble Solids (%)	5.80	0.33	0.40	9.84	10.88	82	1.06	18.31
Ascorbic Acid (mg/100ml)	26.23	4.92	7.31	8.46	10.31	67	3.75	14.29
Titratable acidity	0.56	0.02	0.03	9.97	12.66	62	0.09	16.17
Lycopene mg/100gm	5.86	1.32	1.84	19.62	23.16	72	2.01	34.24

Table-2: Genotypic (G) and phenotypic (P) correlation coefficients among yield and yield contributing traits in tomato

Character		Plant Height	Days to 50% Flowering	Primary Branches/ Plant	No. of Fruits/ Plant	Average Fruit Weight	Fruit diameter	Fruit shape index	Fruits/ Cluster	Total Yield/ Plant	Pericarp Thickness
Plant Height	G	--	-0.30	0.48	0.40	0.29	0.32	0.28	0.46	0.32	0.29
	P	--	-0.29**	0.33**	0.35**	0.24**	0.31**	0.27**	0.43**	0.30**	0.28**
Days to 50% Flowering	G			-0.16	-0.25	-0.04	0.24	-0.22	-0.01	-0.38	0.16
	P			-0.14	-0.20*	-0.05	0.22*	-0.20*	-0.02	-0.34**	0.17
Primary Branches Per Plant	G				0.63	0.61	0.35	0.45	0.79	0.60	0.10
	P				0.46**	0.34**	0.20*	0.33**	0.50**	0.47**	0.05
No. of Fruits /Plant	G					0.66	0.23	0.57	0.58	0.85	0.22
	P					0.45**	0.18*	0.49**	0.42**	0.75**	0.18*
Average Fruit Weight	G						0.41	0.45	0.50	0.56	0.23
	P						0.37**	0.40**	0.45**	0.50**	0.21*
Fruit diameter	G							0.37	0.25	0.13	0.27
	P							0.35**	0.25**	0.11	0.25**
Fruit shape index	G								0.50	0.60	0.25
	P								0.46**	0.55**	0.24**
Fruits Per Cluster	G									0.15	0.25
	P									0.13	0.21*
Total Yield Per Plant	G										0.18
	P										0.15
Pericarp Thickness	G										--
	P										--

Table-3: Genotypic (G) and phenotypic (P) correlation coefficients among quality characters in tomato

Characters		TSS	Ascorbic Acid	Titratable acidity	Lycopene
TSS	G	--	0.19	0.19	0.15
	P	--	0.11	0.14	0.11
Ascorbic Acid	G			0.46	0.63
	P			0.38**	0.53**
Titratable acidity	G				0.79
	P				0.77**
Lycopene	G				--
	P				--

association was reported by Joshi *et al.* (2004), Mayavel *et al*. (2005), Dhankar and Dhankar (2006), Kumar *et al*. (2006), Ara *et al*. (2009), Rajaguru *et al*. (2010), Singh *et al.* (2011), Kumar *et al.* (2012) and Srivastava *et al.* (2013).

Correlation among quality characters are presented in Table-3. Ascorbic acid positively significant correlated with titratable acidity (0.46 and 0.38) and lycopene content (0.63 and 0.53), while titratable acidity positive correlated with lycopene content (0.79 and 0.77) at genotypic and phenotypic level respectively. The correlation of yield with most of the quality traits indicated that simultaneous improvement of yield and quality traits was not possible because of negative correlation of yield with such quality traits similar result were reported by Rani (2010).

Positive relationships of plant height, number of branches per plant, number of fruits per plant and average fruit weight with total yield per plant with adequate availability of genetic variability for these traits in tomato indicate considerable scope of plant canopy modification in tomato leading to higher yield and days to flowering negatively correlated with yield which is desirable character. Increasing plant height will certainly require additional crop caring practices through staking and other canopy supporting measures to get higher harvest per unit area.

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