Genetic Variability, Heritability and Correlation Study for Nutritional Quality Traits in Tomato

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Thirty five genotypes of tomato were evaluated under mid hills conditions in the Experimental Farm, Hawalbagh, VPKAS, Almora during *Kharif* 2007. Significant variation with regard to textural {pericarp thickness, skin firmness, total soluble solids (TSS)}, nutritional {phosphorus (P), potassium (K), iron (Fe), zinc (Zn), copper (Cu), manganese (Mn) and titrable acidity (TA)} and functional (Vitamin 'A', Vitamin 'C' and lycopene) traits were recorded in the genotypes of tomato. The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the traits. High heritability was recorded for Vitamin 'A', lycopene, iron, calcium, pericarp thickness, skin firmness, Vitamin 'C' and TSS whereas, low heritability was observed in case of titrable acidity and phosphorus content in fruits. The genotypic correlations were higher than the corresponding phenotypic for few important quality traits indicating inherent relationship among the nutritional quality traits. Both positive and negative correlations were observed among the traits under study.

Key Words: Tomato, Variability, Correlation, Textural and nutritional quality traits

Introducton

Tomato (*Lycopersicon esculentum* Miller) is an important commercial crop of the world used as raw salad and in processed forms like puree, paste, ketchup, juice, etc. Tomato soup is good remedy for patients suffering from constipation and very good appetizer (Kalloo *et al.*, 2001). It is universally treated as 'Protective Food' since it is a rich source of minerals, vitamins and organic acids. India is the fourth largest producer in the world after China, the USA and Turkey. During 2005-06, the area and production of tomato in the country was about 534.5 thousand ha and 9361.8 thousand metric tonnes, respectively (NHB, 2006), while in Uttarakhand the corresponding figures were 79.97 hundred ha and 86.87 thousand metric tonnes. In North-western Himalayan states, tomato has long cultivation season (March to October) as a summer rainy season and treated as an off-season crop, hence fetches high premium price from the market of North Indian plains. Tomato fruits start coming from hills to the market in the month of mid April to October as during this period tomato fruit supply is poor in the markets, because of restricted tomato cultivation in North Indian plains, poor fruit set during summer (Nandpuri *et al.*, 1971) and leaf curl disease in rainy season restrict the tomato cultivation in Plains.

Exploring natural biodiversity as a source of novel alleles to improve the productivity, adaptation, quality and nutritional value of crop is of prime importance in 21st century breeding programme (Fernie *et al*., 2006). Novel and fast techniques are required for screening biodiversity quickly for important textural and functional properties of tomato. Ahrens and Huber (1990) demonstrated a method of firmness determination using physiological attributes. Storability of tomato is of prime concern in terms of consumer preference and breeders choice. Tomato is called a fruit, which has a fleshy pericarp and soluble solids inside. It is very difficult to measure the fruit firmness by using a hand-operated penetrometer device. Although there is considerable literature on measurement of fruit firmness, very little information is available on storage capacity and germplasm variability for the purpose of quality breeding (Wu and Abbott, 2002). Measurement of tomato firmness with different techniques, *viz.*, universal testing machine, acoustic firmness sensor were reported (Holt, 1970; Ketelaere *et al*., 2004). Pericarp thickness is considered to be very important criteria among breeders for selecting cultivars and it relates to storage capacity. Textural quality of tomato is influenced by firmness of flesh. Flesh firmness is the ratio between pericarp and locular tissue, and skin toughness (Batu, 1998; Lana *et al.,* 2007). Change in firmness is correlated with textural characteristics of tomatoes which relate to colour, shape and flavour. The degree of fruit firmness has been used as an indication of fruit quality (Burton, 1982). However, firmness may be the final index by which the consumer decides to purchase tomatoes (using finger to test tomato firmness) at the time of selection (Gormley and Egan, 1978; Kader *et al.*, 1978). The aim of the present work was to investigate the

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relationship between textural properties such as pericarp thickness and fruit firmness and TSS with nutritional quality traits in order to fasten the screening procedure of tomato germplasm for quality breeding programme.

Materials and Methods

Sampling

Thirty five lines of tomato comprising open pollinated varieties (4), lines (6) and exotic materials (25) from Taiwan were planted in Randomized Block Design in *kharif* season (June–September), 2007, at experimental farm, Hawalbagh (29^{o}36' N, 79^{o}40' E and 1250 m above msl). Tomato fruits were harvested from the experimental field at red (ripe) stage. Fruits from three replicates of 35 lines each were analyzed for different attributes.

Instruments

Estimation of Vitamin 'A' and Vitamin 'C'content in tomato fruits was done by HPLC system (Shimadzu, Japan). For the estimation of potassium, a flame photometer (Systronics 128, India) and for other minerals like iron (Fe), zinc (Zn), copper (Cu), manganese (Mn) an atomic absorption spectrophotometer (Analytik Jena AG, Germany) was used. Phosphorus (P) was estimated photometrically via development of the phospho-molybdate complex. Tomato firmness was measured using Texture Analyzer-XT2i (Stable Micro Systems Ltd., Godalming, UK).

Textural Analysis

Pericarp thickness of tomato was measured using Vernier calliper (Mitutoyo, Japan) after cutting into slices. Tomato fruits firmness was measured using 2 mm cylindrical probe with 50 kg load cell. To obtain a good estimation of fruit texture, measurements were made on four places of fruits from each replicate, and three replicates were carried out. Firmness is the peak force during penetration, which is related to the strength of the flesh under penetration. At harvest TSS were determined in juice in three replicates of two fruits. TSS was measured using a digital refractometer (SR-05A; Sipcon, India)

Chemical Analysis

Titrable acidity (TA) in percentage was determined in juice after extraction in water in three replicates of two tomatoes. TA (%) was measured by titration with 0.1 N NaOH and expressed as citric acid equivalent.

Lycopene was estimated after extraction in acetone, followed by partitioning with petroleum ether. The ether extract was pooled after three extractions, followed by washing with sodium sulfate solution. The extract was measured at 503 nm in spectrophotometer for the lycopene content.

Tomatoes were analyzed for nutrient parameters after di-acid digestion (HNO_3: $HClO_4$; 10:4 v/v). The K content was determined by flame photometry, while Fe, Zn, Cu and Mn contents were analyzed by using an atomic absorption spectrophotometer. Phosphorus (P) was estimated photometrically via development of the phospho-molybdate complex (Taussky and Shorr, 1953).

Statistical Analysis

The genotypic and phenotypic coefficient of variation, heritability (broad sense) were calculated by standard statistical procedure given by Burton and DeVane (1953) and Johnson *et al.* (1955). The genotypic and phenotypic correlation coefficient was calculated by a method described by Singh and Choudhary (1979).

Results and Discussion

Significant variation with regard to all quality traits was recorded in the lines of tomato. Wide variation (0.27-1.14 mg 100 g^{-1}) was observed for Vitamin 'A' content in evaluated tomato lines, Vitamin 'C' content in tomato lines ranged from 12.0-86.0 mg 100 g^{-1}, consistent with the report by Franke *et al.* (2004). Lycopene content in evaluated genotype of tomato ranged from 0.58-4.92 mg 100 g^{-1}, consistent with previous reports (Thompson *et al.*, 2000). Among textural attributes, pericarp thickness and total soluble solid ranged between 1.41-4.87 mm and 2.0-4.0%, respectively, consistent with earlier reports (Saltveit, 2005). Skin firmness ranged from 273.7-611.7 g, consistent with previous report (Powell *et al.*, 2003, Mizrach, 2007). Titratable acidity in tomato juice ranged from 0.12-0.50 %. Phosphorus, potassium, Iron, zinc, copper and manganese content in tomato fruit ranged between 33.35-53.17 mg 100 g^{-1}, 228.8-371.15 mg 100 g^{-1}, 611-1772.2 g 100 g^{-1}, 67.76-154.9 g 100 g^{-1}, 9.39-40.53 g 100 g^{-1} and 108.55-197.3 g 100 g^{-1}, respectively.

A perusal of data (Table 1) revealed that phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were observed high for almost all the traits under study except phosphorus, potassium and manganese content in fruits. These results indicated that traits showing the higher magnitude of coefficient of variation offer a better opportunity for improvement through selection. These results are in broad conformity to those of Manohar *et al.* (1981) and Meena *et al.* (2003).

Table 1. Range, Mean, Variance, Coefficient of variation, Heritability (broad sense) and Genetic Advancement for different quality traits in tomato lines

Traits	Range	Mean	Variance		Coefficient of variation (%)		Heritability in broad sense (%)	Genetic advance (5%)
			Genotypic	Phenotypic	Genotypic	Phenotypic		
Vit-A (mg/100 g)	0.27-1.14	0.61	0.050	0.050	36.347	36.394	99.7	0.459
Vit-C (mg/100 g)	12.00-86.00	40.26	419.462	479.726	50.875	54.407	87.4	39.451
Lycopene (mg/100 g)	0.58-4.24	1.99	0.657	0.691	40.599	41.633	95.1	1.629
Pericarp thickness (mm)	1.41-4.87	3.19	0.675	0.678	25.766	25.831	99.5	1.688
Skin firmness (g)	273.7-611.7	439.84	7328.128	7760.694	19.467	20.033	94.4	171.360
TSS (%)	2.0-4.0	2.89	0.347	0.411	20.766	22.579	84.6	1.117
Titr acid (%)	0.12-0.50	0.29	0.006	0.015	27.674	42.517	42.4	0.108
P (mg 100 g^{-1})	33.35-53.17	39.90	19.868	43.367	11.173	16.508	45.8	6.215
K (mg 100 g^{-1})	228.8-371.15	276.95	1082.010	1250.397	11.904	12.797	86.5	63.034
Fe (µg 100 g^{-1})	611-1772.2	918.23	45140.450	45523.550	23.141	23.239	99.2	435.828
Zn (µg 100 g^{-1})	67.76-154.90	116.52	648.534	730.978	21.856	23.204	88.7	49.414

The high heritability coupled with high genetic advance was recorded in skin firmness, Vitamin 'C', Cu, Fe, K, Zn and Mn content in fruits indicating the involvement of additive gene action for expression of theses traits. Therefore, selection based on phenotypic performance of these traits would be more effective to select better lines. Johnson *et al.* (1955) has suggested that traits with high heritability coupled with high genetic advance would respond to selection better than those with high heritability and low genetic advance. Heritability is not an exact parameter because it could be high even when genetic advance is very low. However, expected genetic gain can be high only if the genetic variance is high (Allard, 1960). Burton (1953) suggested that GCV along with heritable estimates would give a better picture of the amount of progress expressed by phenotypic selection.

The assessment of genetic potentiality of important quality traits and their association is of paramount importance to carryout the effective selection for marking genotype with desired quality traits. Correlation coefficient of important quality traits were estimated at genotypic and phenotypic levels (Table 2).

In the present study, the genotypic correlation coefficients were significantly higher in magnitude than their respective phenotypic ones for few of the associations. Indicated that in these associations there was inherited relationship between the traits under study and environment had not played much role in reducing their actual association. From these associations, it appeared that Vitamin 'C' was significantly and positively correlated with zinc content in fruit while it was significantly and negatively correlated with pericarp thickness and skin firmness. Significant and positive correlation was found among Vitamin 'A', titrable acidity and phosphorus content in fruit. Lycopene was significantly and positively correlated with potassium content in fruit. Pericarp thickness was positively correlated with skin firmness and phosphorus content in fruit similarly positive correlation was also found between skin firmness and phosphorus content in fruit. TSS was found positively correlated with phosphorus content in fruit whereas, titrable acidity was found negatively correlated with potassium content in fruit. Among nutrients, phosphorus was significantly and positively correlated with zinc and copper content in fruit, zinc had also positive correlation with copper whereas, potassium was found negatively correlated with manganese content in fruit. Result of the present study will help in selection of genotypes in nutritional quality improvement program of tomato.

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Table 2. Genotypic (r_g) Phenotypic (r_P) correlation coefficient among different quality traits in tomato lines

Traits		Vit-A	Vit-C	Lycopene	Pericarp thickness	Skin firmness	TSS	Titr acid	P	K	Fe	Zn	Cu	Mn
		(mg/100 g)			(mm)	(g)	(%)	(%)	(mg 100 g^{-1})		(µg 100 g^{-1})			
Vit-A (mg/100 g)	r_g	1.000	-0.020	-0.139	-0.008	0.177	-0.192	0.414*	0.402*	-0.135	-0.177	0.146	0.240	0.122
	r_P	1.000	-0.003	-0.128	0.009	0.163	-0.177	0.287	0.305	-0.126	-0.177	0.138	0.234	0.110
Vit-C (mg/100 g)	r_g		1.000	0.281	-0.355*	-0.333*	-0.257	0.126	-0.016	0.300	0.124	0.485**	0.215	0.057
	r_P		1.000	0.307	-0.325*	-0.353*	-0.208	0.158	0.237	0.260	0.116	0.431**	0.198	0.038
Lycopene (mg/100 g)	r_g			1.000	-0.080	-0.136	-0.187	-0.069	0.018	0.424*	-0.196	0.173	-0.008	0.029
	r_P			1.000	-0.076	-0.145	-0.164	0.002	0.116	0.389*	-0.188	0.155	-0.002	0.027
Pericarp thickness (mm)	r_g				1.000	0.492**	0.239	-0.054	0.376*	-0.239	0.135	0.019	0.135	0.054
	r_P				1.000	0.477**	0.216	-0.037	0.259	-0.226	0.135	0.021	0.132	0.048
Skin firmness (g)	r_g					1.000	0.322	0.275	0.361*	-0.172	0.017	0.079	0.034	-0.296
	r_P					1.000	0.315	0.114	0.128	-0.162	0.020	0.055	0.029	-0.274
TSS (%)	r_g						1.000	0.143	-0.038	-0.449**	-0.133	-0.246	-0.114	0.091
	r_P						1.000	0.077	-0.009	-0.390*	-0.125	-0.240	-0.130	0.077
Titr acid (%)	r_g							1.000	0.049	-0.361*	-0.072	0.060	-0.079	0.341*
	r_P							1.000	0.228	-0.232	-0.055	-0.013	-0.050	0.187
P (mg 100 g^{-1})	r_g								1.000	-0.151	0.266	0.676**	0.541**	-0.062
	r_P								1.000	-0.099	0.178	0.433**	0.357*	-0.060
K (mg 100 g^{-1})	r_g									1.000	-0.089	0.113	-0.119	-0.447**
	r_P									1.000	-0.084	0.098	-0.092	-0.301
Fe (µg 100 g^{-1})	r_g										1.000	0.315	0.099	-0.039
	r_P										1.000	0.292	0.101	-0.046
Zn (µg 100 g^{-1})	r_g											1.000	0.623**	-0.129
	r_P											1.000	0.569**	-0.093
Cu (µg 100 g^{-1})	r_g												1.000	-0.031
	r_P												1.000	-0.029
Mn (µg 100 g^{-1})	r_g													1.000
	r_P													1.000

*, ** Significant at 5% and 1% level, respectively

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