Genetic Variability and Correlation Studies in Pomegranate (*Punica granatum* L.)

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Genetic variability studies in ten cultivars including one local check of pomegranate (*Punica granatum* L.) revealed that phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the traits. High heritability coupled with high genetic gain were recorded for plant height, fruit volume, fruit set percentage, acidity, gross fruit yield, rind weight and number of fruits/plant. Moderate to high heritability with low genetic gain were observed for fruit diameter, rind thickness, rind weight. TSS, total sugars and juice content. The genetic correlation were higher than corresponding phenotypic ones for most of the characters implying inherent relationship among them. Gross fruit yield expressed positive and significant genotypic and phenotypic correlation with fruit weight, fruit diameter, fruit volume, juice content, fruit set percentage and number of fruit/plant.

Key words: Correlation, Genetic variability, Pomegranate, Yield

Pomegranate (*Punica granatum* L.) locally known as 'Anar' belong to family Punicaceae. It is one of the favourite table fruits of tropical and sub-tropical regions of the world. It is highly valued for its delicious fruits and possesses ornamental and pharmaceutical properties. The species however, can adopt a wide range of agro-climatic conditions. It is deciduous in low winter temperature areas but evergreen or partially deciduous in tropical and sub-tropical regions. However, its production is very low and unstable. Systematic efforts are lacking in genetic improvement of the crop. Improvement in any crop depends on the magnitude of genetic variability association between various characters and the extent of transmission of characters from one generation to the next. Therefore, it is essential to partition the overall variability into its heritable and non-heritable components, which will enhance the precision of selection.

Gross fruit yield is a complex trait influenced by several factors interacting with environment. Success of any breeding programme for its improvement depends on the existing genetic variability in the base population and on the efficiency of selection. However, knowledge on the inter-relationship of characteristics of a crop is of paramount importance as it helps in selecting appropriate components which would result in the improvement of complex characteristics that are correlated with each other. Hence, studies on genetic variability, and correlation studies among various plant and fruit characteristics in pomegranate crop were conducted.

Materials and Methods

The plant material consisting of 10 pomegranate cultivars including one Local check, *viz.* Kabuli Kandhari, Chawla, Ganesh, Mridula, Jyoti. G-137, Dholka, Bedana, Kandhari and Local check were used in the present investigation. The experiment was carried out at Research Farm of Central Institute of Temperate Horticulture (CITH), Srinagar (Jammu & Kashmir) in a Randomized Block Design with three replications during 2005. Six year old plants were selected at a distance of 2.5 m x 2.5 m. The recommended cultural practices were followed during the studies. Observations were recorded on fifteen characteristics *viz.* plant height (cm), plant spread (cm), days to first flowering, fruit weight (g), fruit diameter (cm), fruit volume (cm^1), rind thickness (mm), rind weight (g), TSS (%), acidity (%), TSS/acid ratio, juice content (%), fruit set (%) and number of fruits/plant and gross fruit yield (kg/plant). The genotypic and phenotypic coefficients of variation, heritability in a broad sense and expected genetic gain as per cent of mean were calculated by standard statistical procedure (Burton and De Vane 1953; *Johnson et al.*, 1955). The correlation coefficients were calculated by a method described by Singh and Choudhary (1979).

Result and Discussion

The analysis of variance for fifteen quantitative characters revealed that mean sum of squares were significant for

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all. Based on the mean performance of fruit yield, cv. Dholka was found higher yielder followed by Bedana, Kandhari, Kabuli Kanhdari and G-137 (Table 1). The range and mean values revealed higher variation for plant height, plant spread, fruit weight, fruit volume and rind weight while as for rest of the traits it was medium to low. A perusal of the data depicted in Table 2 revealed that phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were high for gross fruit yield, fruit set, number of fruits/plant, acidity and fruit volume. The low PCV and GCV were observed in traits viz. TSS, juice content and fruit diameter. The remaining traits showed medium range of PCV and GCV. This indicated that the characters showing 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).

The estimates of heritability indicate the effectiveness with which selection can be expected to exploit the existing genetic variability (Burton and Devane (1953); Johnson *et al.* (1955). In the present study, generally estimates of heritability were high for all the characters. Fruit diameter, plant height, fruit volume, rind weight, plant spread, gross fruit yield, number of fruits/ plant, fruit set, days to first flowering and fruit weight recorded the highest heritability while the other traits showed low to moderate heritability. High heritability in broad sense indicated that large proportion of phenotypic variance was attributed to the genotypic variance and that difference for these characters among the cultivars were real and traits were less influenced by the environment and selection based on phenotypic performance for these traits would be effective. The results obtained from the present study are in agreement with the findings of Attri *et al.* (1999), Pandey and Bist (1998) and Meena *et al.* (2003).

Heritability is not an absolute parameter because it could be high even when genetic variance is low. However, expected genetic gain can be high only if the genetic variance is high (Allard, 1960). Burton (1953) advocated that GCV along with heritable estimates would furnish a better picture of the amount of progress expressed by phenotypic selection. The characters exhibiting comparatively lower heritability accompanied by low genetic gain indicate that dominance or epistatic effects are of considerable value for these characters and hence little improvement in these characters is possible through selection. The results are in accordance with the findings of Panse (1957). The expected genetic gain (% of mean) was high for gross fruit yield, fruit set, number of fruits/plant, acidity, fruit volume and plant height. High genetic gain for acidity and low for TSS was reported by Manohar *et al.* (1981) and Meena *et al.* (2003). The results also coincide with the findings of Pandey and Bist (1998).

The GCV estimates are useful in studying the extent of variability in different characters as it measures the range of genetic variability. The high values of heritability coupled with high GCV and expected genetic gain were observed for gross fruit yield, fruit set, number of fruits/

Table 1. Range, mean, variance, coefficients of variation, heritability and expected genetic gain for different important characters in pomegranate

Character	Range	General mean	Variance		Coefficient of variation (%)		Heritability in broad sense (%)	Expected genetic gain (%)
			Genotypic	*Phenotypic*	*Genotvpic*	*Phenotypic*		of mean)
Plant height (cm)	85.77-180.99	132.48	850.03	861.51	22.01	*22.05*	98.7	45.03
Plant spread (cm)	79.20-135.33	114.99	332.48	334.30	15.86	16.14	96.6	32.09
Days taken to first flower opening	50.00-76.66	59.06	59.84	66.00	13.10	13.75	90.7	25.68
Fruit weight (g)	111.29-232.92	181.15	1375.36	1522.68	20.47	21.54	90.3	40.08
Fruit diameter (cm)	5.77-7.65	6.88	0.32	0.33	8.29	8.34	98.8	17.00
Fruit volume (cm^3)	100.80-234.85	173.74	1688.43	1711.86	23.65	23.81	98.6	48.38
Rind thickness (mm)	2.94-4.24	3.76	0.28	0.40	14.10	16.83	70.2	24.44
Rind weight (g)	50.57-75.20	64.80	96.37	97.83	15.15	15.26	98.5	30.97
TSS (%)	13.72-15.85	14.99	0.50	1.07	4.72	6.90	46.8	6.66
Acidity (%)	0.43-0.82	0.54	0.02	0.03	26.09	28.57	83.4	49.27
TSS/ acid ratio	19.43-34.87	28.99	26.60	42.76	17.78	22.55	62.2	28.89
Juice content (%)	42.23-50.93	47.81	9.57	10.76	6.47	6.86	88.9	12.56
Fruit set (%)	26.15-67.46	39.74	219.56	241.79	37.25	39.13	90.5	73.19
Number of fruits plant"	14.21-43.10	216.34	82.46	89.15	34.48	35.85	92.5	68.29
Gross fruit yield (kg/plant)	1.57-9.38	5.01	6.13	6.62	49.27	51.20	92.6	97.69

Table 2. Genotypic (r_g), Phenotypic (r_p) and Environmental (r_e) correlation coefficients among different important characters in pomegranate

Character		Plant height (cm)	Plant spread (cm)	Days taken to flower opening	Fruit weight (g)	Fruit diameter (cm)	Fruit volume (cm^j)	Rind thickness (mm)	Rind weight (g)	TSS (%)	Acidity (%)	TSS/ acid ratio	Juice (%)	Fruit set (%)	Number of fruits $plant^{-1}$	Gross fruit yield ($kg\,plant^{-1}$)
Plant height (cm)	r_g	1.000	0.902**	-0.6%*	0.328	0.372	0.333	0.760*	0.326	-0.228	-0.155	0.035	0.371	0. 176	0.542	0.405
	r_p	1.000	0.877**	-0.663*	0.306	0.371	0.331	0.641*	0.318	-0,124	-0.141	0.038	0.342	0. 169	0.517	0.384
	r_e	1.000	-0.156	-0.153	-0.103	0.2(5	0.221	0. 125	-0.273	0.364	-0.001	0.145	-0.149	0.076	-0.032	-0.086
Plant spread (cm)	r_g		1.000	-0.736*	0.550	0.535	0.502	0.698*	0.442	-0.197	-0.166	0.071	0.580	0.403	0.691*	0.595
	r_p		1.000	-0.673*	0.480	0.521	0.488	0.586	0.429	-0.127	-0.177	0.093	0.543	0,384	0.649*	0.545
	r_e		1.000	0.287	-0.586	-0.107	-0.100	0.108	-0.070	0.041	-0.381	0.338	0.083	0,120	-0.077	-0.333
Days taken to first flower opening	r_g			1.000	-0.006	-0.023	0.007	-0.603	-0.225	0.657*	0.752*	-0.736*	-0.195	-0.074	-0.315	-0.153
	r_p			1.000	-0.014	-0.024	0.004	-0,467	-0.206	0.404	0.589	-0.485	-0.160	-0.062	-0.294	-0.152
	r_e			1.000	-0.094	-0.052	-0,068	0.089	0.188	-0.106	-0.520	0.359	0.151	0.059	-0.064	-0.149
Fruit weight (g)	r_g				1.000	0.870**	0.891**	0.156	0.775"	0.596	0.283	-0.268	0.926**	11.831**	0.823**	0.914**
	r_p				1.000	0,721*	0.735"	0.055	0.732"	0.272	0.307	-0.276	0.870**	0.728*	0.779**	0.908**
	r_e				1.000	0.426	0.429	-0.408	0.021	-0.507	0.484	-0.394	0.382	-0.263	0.322	0.693
Fruit diameter (cm)	r_g					1.000	0.765**	0.206	0.801"	0.537	0.324	-0.326	0.910**	0.783**	0.800* *	0.894**
	r_p					1.000	0.540	0.150	0.787"	0.371	0.305	-0.258	0.870**	11.740*	0.771**	0.859**
	r_e					1.000	0.792**	-0.375	-0,231	0.071	0.244	-0.027	0.454	-0.063	0.194	0.355
Fruit Volume (cm^3)	r_g						1.000	0.166	0.797"	0.564	0.345	-0.340	0.904**	11.811**	0.799**	0.868**
	r_p						1.000	0.114	0.782"	0.389	0.324	-0.269	0.864**	0.767**	0.770**	0.866**
	r_e						1000	-0.373	-0.204	0.064	0.242	-0.040	0.451	-0.041	0.209	0.378
Rind thickness (mm)	r_g							1.000	0.102	0.671*	0.038	-0.191	0.366	0.123	0.230	0.136
	r_p							1.000	0.093	-0.242	-0.025	-0.074	0.259	0.063	0.134	0.052
	r_e							1.000	0.119	0.359	-0.240	0.157	-0.169	-0.211	-0.346	-0.353
Rind weight (g)	r_g								1.000	0.480	0.055	0.036	0/.31	0.520	0.560	0.628
	r_p								1.000	0.305	0.046	0.010	0.594	0.501	0.540	0.605
	r_e								1.000	-0.233	-0.063	-0.242	0.071	0.241	0.171	0.174
TSS (%)	r_g									1.000	0.853**	-0.847**	0.138	0.548	0.437	0.550
	r_p									1.000	0.479	-0.273	-0.020	0.367	0.225	0.278
	r_e									1.000	-0.181	0.412	-0.451	0.038	-0.314	-0.423
Acidity (%)	r_g										1.000	-0.890**	0,057	0.379	0.105	0.195
	r_p										1.000	0.812**	0.069	0.2S2	0.097	0.185
	r_e										1.000	-0.889**	0.145	-0.390	0.039	0.299
TSS/ acid ratio	r_g											1.000	-0.070	-0.379	-0.140	-0.204
	r_p											1.000	-0.094	-0.217	-0.125	-0.189
	r_e											1.000	-0.203	0.363	-0.112	-0.306
Juice (%)	r_g												1.000	0.724*	0.714*	0.767**
	r_p												1.000	0.649*	0.700-	0.734*
	r_e												1.000	-0.022	0.582	0.599
Fruit set (%)	r_g												1.000	0.868**	0.911**	
	r_p													1.000	0.814**	0.889**
	r_e													1.000	0.231	0.078
Number of fruits $plant^{-1}$	r_g														1.000	0.967**
	r_p														1.000	0.942**
	r_e														1.000	0.871**
Gross fruit yield ($kg\ plant^{-1}$)	r_g															1.000
	r_p															1.000
	r_e															1.000

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

plant and acidity. This might be attributed to additive gene action controlling their expression and phenotypic selection for their amelioration could be brought about by simple method like mass selection or bulk method after hybridization in early generations. Moderate to high estimates of heritability accompanied by low GCV and expected genetic gain were noticed for TSS, juice content, fruit diameter and days taken to first flowering. It may be inferred that these characters were conditioned by non-additive gene action and high genotypic environment interaction. The heritability is being exhibited due to favourable influence of environment rather than the genotypic and simple selection would be rewarding. The present results confirm to those of Rekha and Prasad (1993) and Meena *et al.* (2003).

Correlation coefficients of important economic characters between gross fruit yield and its component traits were estimated at genotypic (g), phenotypic (p) and environmental (e) levels (Table 2). In the present study, the genotypic correlation coefficients were higher in magnitude than their respective phenotypic ones for most of the associations. This suggested that there was inherited relationship between the traits under study and environment had not played much sole in reducing their actual association. From these association, it appeared that gross fruit yield was significantly and positively correlated with fruit weight, fruit diameter, fruit volume, juice content, fruit set and number of fruits/ plant. Positive association of plant height with plant spread have also been reported by Ram Asrey and Shukhla (2003) and fruit weight with fruit diameter by Pandey and Bist (1998).

Fruit weight and number of fruits have an important contribution to gross fruit yield. In the present investigation, fruit weight had positive and significant correlation with fruit diameter, fruit volume, juice content, fruit set and number of fruits/plant and gross fruit yield; fruit diameter and volume with fruit volume (only for fruit diameter), rind weight, juice content, fruit set, number of fruits/plant and gross fruit yield; juice content with fruit set, number of fruits/plant and gross fruit yield; fruit set with number of fruits/plant and gross fruit yield; and number of fruits/ plant with gross fruit yield. Verma *et al.* (2002) in strawberry reported positive correlations of fruit weight with fruit diameter and fruit volume. Results of present study showed that plant height, fruit weight fruit diameter, fruit volume, juice content, fruit set and number of fruits/plant had positive significant correlation with gross fruit yield. Hence, these characters contribute towards the yield efficacy of a pomegranate plant. Therefore, these characters are ideal criterion for selection of pomegranate crop regarding yield.

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