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Correlation and path coefficient analysis in pomegranate (*Punica granatum* L.)

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ABSTRACT

Studies were carried out to find out association between different characters and magnitude of association of different characters with gross fruit yield (kg/plant) in ten cultivars of pomegranate (*Punica granatum* L.) including one local check. Data revealed that genotypic correlation coefficients were higher than their corresponding phenotypic ones for most of the characters, implying an inherent relationship among them. Fruit weight, fruit diameter, fruit volume, juice content, fruit set and number of fruits/plant exhibited highly significant positive correlation. Among the characters studied, number of fruits/ plant, fruit weight, fruit volume and fruit set recorded maximum positive direct effect towards gross fruit yield (kg/ plant) at both the levels. This study revealed that both the number of fruits/plant and fruit weight could form a selection criterion for yield improvement in pomegranate.

Key words: Pomegranate, correlation, path analysis

INTRODUCITON

Pomegranate (*Punica granatum* L.) is an important fruit in tropical and sub-tropical countries. In India, its cultivation is scattered all over the country, especially in the states of Maharashtra, Gujarat, Andhra Pradesh, Uttar Pradesh, Tamil Nadu and Karnataka. However, no systematic work has been done on improvement of the pomegranate crop. Correlation studies help in finding out the degree of inter-relationship among various characters and in evolving selection criteria for improvement, and, path coefficient analysis provides a better index for selection than mere correlation coefficient by separating the correlation coefficients of yield and its components into direct and indirect effects. Therefore, the present study was carried out to find out all possible component characters for improvement of this crop through character association and path-coefficient analysis.

MATERIAL AND METHODS

The present investigation was carried out at the Research Farm of Central Institute of Temperate Horticulture (CITH), Srinagar, during 2004. Ten pomegranate cultivars, viz., Kabuli Kandhari, Chawla, Ganesh, Mridula, Jyoti, G-137, Dholka, Bedana, Kandhari and one local check were used in the study. The experiment was laid out in randomized block design with three replications. Five year old plants of uniform vigour were selected and spaced at 2.5m x 2.5m. All the recommended cultural practices were followed. Observations were recorded on three randomly selected plants per replication for each cultivar for fifteen important characters, including gross fruit yield (kg/plant). Correlations were worked out as per Al-jibouri *et al* (1958) and path coefficient analysis was performed as per the method proposed by Dewey and Lu (1959).

RESULTS AND DISCUSSION

In a majority of the characters studied, genotypic correlation coefficient was found to be higher in magnitude than phenotypic correlation coefficient, indicating a strong inherent association among various characters (Table 1). The study revealed positive and significant correlation between plant height, plant spread and rind thickness but a negative association with days to first flower opening. Plant spread exhibited positive and significant association with fruit weight, fruit diameter, fruit volume and juice content, number of fruits/ plant and gross fruit yield only at the genotypic level. Highly significant correlation was observed between fruit weight, fruit diameter, fruit volume, rind weight, juice content, fruit set, number of fruits/plant and gross fruit yield and between fruit diameter with the same characters of fruit weight. Positive association of plant

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Table 1. Genotypic (G), Phenotypic (P) and Environmental (E) correlation coefficients of some important characters in pomegranate cultivars on gross fruit yield under temperate climatic conditions of Kashmir

Character		Plant height (cm)	Plant spread (cm)	Days to first flower opening	Fruit weight (g)	Fruit diameter (cm)	Fruit valume (cm^3)	Rind thickness (mm)	Rind weight (g)	TSS (%)	Acidity (%)	TSS/ Acid ratio	Juice (%)	Fruit set (%)	Number of fruits / plant	Gross fruit yield (kg/plant)
(1)		*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*	*(16)*
Plant height	G	1.000	0.632*	-0.693*	0.063	0.067	0.032	0.738*	0.132	-0.249	-0.110	-0.011	0.078	0.059	0.319	0.147
(cm)	P	1.000	0.597	-0.665*	0.066	0.063	0.021	0.650*	0.128	-0.213	-0.104	0.002	0.071	0.040	0.247	0.131
	E	1.000	0.055	0.022	0.202	0.061	0.085	0.045	0.314	0.420	-0.123	0.283	0.016	-0.558	-0.021	0.005
Plant spread	G		1.000	-0.655*	0.749*	0.706*	0.674*	0.558	0.745*	-0.049	-0.213	0.169	0.741*	0.476	0.817**	0.743*
(cm)	P		1.000	-0.635*	0.633*	0.669*	0.637*	0.444	0.605	-0.072	-0.187	0.115	0.586	0.465	0.537	0.557
	E		1.000	-0.431	-0.472	0.122	0.090	-0.142	0.003	-0.242	0.202	-0.227	-0.354	0.358	-0.343	-0.531
Days to first	G			1.000	0.001	0.028	0.056	-0.672*	-0.226	0.560	0.644*	-0.579	-0.118	-0.024	-0.353	-0.146
flower opening	P			1.000	0.018	0.031	0.058	-0.559	-0.224	0.534	0.618	-0.508	-0.057	-0.042	-0.186	-0.062
	E			1.000	0.221	0.137	0.123	0.115	-0.281	0.342	0.137	-0.008	0.408	-0.253	0.498	0.572
Fruit weight (g)	G				1.000	0.906**	0.804**	0.117	0.868**	0.492	0.305	-0.249	0.921**	0.839**	0.910**	0.956**
	P				1.000	0.813**	0.760*	0.108	0.662*	0.430	0.300	-0.250	0.790**	0.727*	0.651*	0.894**
	E				1.000	0.541	0.558	0.311	-0.280	-0.040	0.269	-0.276	-0.045	-0.472	-0.161	-0.211
Fruit Diameter	G					1.000	0.910**	0.093	0.879**	0.515	0.335	-0.275	0.901**	0.794**	0.863**	0.924**
(cm)	P					1.000	0.823**	0.112	0.742*	0.473	0.333	-0.264	0.806**	0.749*	0.644*	0.822**
	E					1.000	0.603	0.548	-0.025	-0.009	0.432	-0.321	-0.061	-0.167	-0.379	-0.178
Fruit Volume	G						1.000	0.075	0.871**	0.539	0.355	-0.288	0.875**	0.820**	0.873**	0.943**
(cm^3)	P						1.000	0.051	0.734*	0.496	0.352	-0.275	0.781**	0.773**	0.647*	0.831**
	E						1.000	0.533	-0.044	0.009	0.438	-0.312	-0.086	0.169	-0.420	-0.213
Rind thickness	G							1.000	0.059	-0.580	-0.049	-0.143	0.295	0.112	0.199	0.085
(mm)	P							1.000	0.086	-0.459	-0.040	-0.088	0.283	0.045	0.083	0.055
	E							1.000	0.168	0.082	-0.282	0.132	0.238	-0.361	-0.186	-0.057
Rind weight (g)	G								1.000	0.425	0.089	-0.021	0.660*	0.616	0.679*	0.749*
	P								1.000	0.349	0.043	0.061	0.542	0.482	0.543	0.613
	E								1.000	0.073	-0.329	0.346	0.152	-0.127	0.279	0.174
TSS (%)	G									1.000	0.663*	-0.507	0.211	0.605	0.514	0.561
	P									1.000	0.575	-0.305	0.207	0.497	0.369	0.457
	E									1.000	-0.402	0.745*	0.192	-0.343	-0.014	-0.054
Acidity (%)	G										1.000	-0.971**	0.101	0.395	0.162	0.262
	P										1.000	-0.930**	0.082	0.387	0.118	0.232
	E										1.000	-0.839**	-0.102	0.280	-0.062	-0.017
TSS/ Acid ratio	G											1.000	-0.055	-0.289	-0.095	-0.187
	P											1.000	-0.027	-0.275	-0.054	-0.159
	E											1.000	0.101	-0.195	0.053	-0.035
Juice (%)	G												1.000	0.705*	0.694*	0.781**
	P												1.000	0.551	0.618	0.710*
	E												1.000	-0.475	0.476	0.414
Fruit set (%)	G													1.000	0.830**	0.875**
	P													1.000	0.759*	0.846**
	E													1.000	-0.106	-0.242
Number of fruits/	G														1.000	0.916**
plant	P														1.000	0.877**
	E														1.000	0.818**
Gross fruit yield	G															1.000
(kg/ plant)	P															1.000
	E															1.000

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

Table 2. Direct and indirect effects (at the genotypic level) of important characters on gross fruit yield in pomegranate cultivars under temperate climatic conditions of Kashmir

Character	Plant height (cm)	Plant Spread (cm)	Days to first flower opening	Fruit weight (g)	Fruit diameter (cm)	Fruit volume (cm^3)	Rind thickness (mm)	Rind weight (g)	TSS (%)	Acidity (%)	TSS/ Acid ratio	Juice (%)	Fruit set (%)	Number of fruits / plant	Correlation coefficient with gross fruit yield (kg/plant)
Plant height (cm)	**0.028**	-0.074	-0.072	0.035	-0.020	0.006	0.024	0.005	0.002	0.020	0.001	-0.005	0.008	0.187	0.147
Plant spread (cm)	0.018	**-0.117**	-0.068	0.414	-0.204	0.136	0.018	0.028	0.001	0.039	-0.013	-0.050	0.062	0.480	0.743 *
Days to first flower opening	-0.020	0.076	**0.104**	0.001	-0.008	0.011	-0.022	-0.009	-0.005	-0.117	0.045	0.008	-0.003	-0.207	-0.146
Fruit weight (g)	0.002	-0.170	0.001	**0.552**	0.084	0.111	0.003	0.022	-0.064	-0.135	0.010	-0.074	0.109	0.501	0.956 **
Fruit diameter (cm)	0.004	-0.082	0.002	0.555	**-0.289**	0.201	0.006	0.033	-0.016	-0.060	0.021	-0.061	0.104	0.507	0.924 **
Fruit volume (cm^3)	0.001	-0.079	0.006	0.554	-0.288	**0.202**	0.003	0.032	-0.006	-0.064	0.022	-0.059	0.107	0.512	0.943 **
Rind thickness (mm)	0.021	-0.065	-0.070	0.048	-0.027	0.010	**0.033**	0.002	0.005	0.003	0.011	-0.020	0.015	0.117	0.085
Rind weight (g)	0.004	-0.087	-0.023	0.479	-0.221	0.176	0.002	**- 0.038**	-0.004	-0.016	0.008	-0.045	0.112	0.398	0.749 *
TSS (%)	-0.007	0.006	0.058	0.271	-0.149	0.109	-0.019	0.016	**-0.009**	-0.120	0.039	-0.014	0.079	0.302	0.561
Acidity (%)	-0.003	0.025	0.067	0.168	-0.097	0.071	-0.001	0.003	-0.006	**-0.181**	0.075	-0.007	0.052	0.095	0.262
TSS/Acid Ratio	0.001	-0.020	-0.060	-0.137	0.080	-0.058	-0.005	-0.001	0.005	0.176	**-0.077**	0.004	-0.038	-0.056	-0.187 **
Juice (%)	0.005	-0.086	-0.012	0.509	-0.261	0.177	0.010	0.025	-0.002	-0.018	0.004	**-0.068**	0.092	0.407	0.781 **
Fruit set (%)	0.002	-0.152	-0.046	0.413	0.092	0.141	0.004	0.013	-0.052	0.142	0.022	-0.060	**0.131**	0.509	0.875 **
Number of fruits / plant	0.009	-0.120	-0.037	0.402	0.110	0.150	0.007	0.016	-0.039	-0.129	0.007	-0.047	0.102	**0.587**	0.916 **

Residual effect = 0.0023

Bold and underlined values indicate direct effects

Table 3. Direct and indirect effects (at the phenotypic level) of important characters on gross fruit yield in pomegranate cultivars under temperate climatic onditions of Kashmir

Character	Plant height (cm)	Plant Spread (cm)	Days to first flower opening	Fruit weight (g)	Fruit diameter (cm)	Fruit volume (cm^3)	Rind thickness (mm)	Rind weight (g)	TSS (%)	Acidity (%)	TSS/ Acid ratio	Juice (%)	Fruit set (%)	Number of fruits / plant	Correlation coefficient with gross fruit yield (kg/plant)
Plant height (cm)	**0.008**	-0.037	-0.061	0.037	-0.024	0.007	0.018	0.005	0.003	0.009	0.001	-0.004	0.004	0.168	0.131
Plant spread (cm)	0.005	**-0.062**	-0.058	0.353	-0.242	0.141	0.012	0.018	0.001	0.015	-0.002	-0.034	0.046	0.364	0.557
Days to first flower opening	-0.006	0.040	**0.092**	0.010	-0.011	0.013	-0.015	-0.007	-0.009	-0.049	0.009	0.003	-0.004	-0.126	-0.062
Fruit weight (g)	0.010	-0.162	0.002	**0.558**	0.036	0.105	0.002	0.020	-0.047	-0.086	0.006	-0.062	0.071	0.441	0.894 **
Fruit diameter (cm)	0.002	-0.042	0.004	0.544	**-0.361**	0.220	0.003	0.023	-0.008	-0.027	0.005	-0.047	0.073	0.434	0.822 **
Fruit volume (cm^3)	0.001	-0.040	0.005	0.543	-0.360	**0.221**	0.004	0.022	-0.009	-0.028	0.003	-0.046	0.076	0.439	0.831 **
Rind thickness (mm)	0.006	-0.028	-0.051	0.065	-0.040	0.017	**0.027**	0.003	0.008	0.005	-0.002	-0.017	0.004	0.053	0.055
Rind weight (g)	0.001	-0.038	-0.021	0.370	-0.268	0.162	0.002	**0.031**	-0.006	-0.003	-0.001	-0.032	0.047	0.368	0.613
TSS (%)	-0.002	0.005	0.049	0.240	-0.171	0.109	-0.010	0.011	**-0.018**	-0.046	0.006	-0.014	0.051	0.248	0.457
Acidity (%)	-0.001	0.012	0.057	0.168	-0.119	0.078	-0.003	0.001	-0.010	**-0.080**	0.017	-0.005	0.038	0.080	0.232
TSS/Acid Ratio	0.001	-0.007	-0.046	-0.140	0.095	-0.061	-0.002	0.002	0.005	0.071	**-0.018**	0.006	-0.027	-0.037	-0.159
Juice (%)	0.003	-0.037	-0.005	0.441	-0.291	0.172	0.008	0.017	-0.004	-0.007	0.001	**-0.059**	0.054	0.417	0.710 *
Fruit set (%)	0.011	-0.129	-0.024	0.306	0.078	0.131	0.001	0.015	-0.019	-0.031	0.005	-0.032	**0.098**	0.514	0.846 **
Number of fruits / plant	0.002	-0.134	-0.017	0.357	0.103	0.143	0.005	0.017	-0.015	-0.038	0.004	-0.036	0.074	**0.618**	0.877 **

Residual effect = 0.0030
Bold and underlined values indicate direct effects

height with spread was also noticed in earlier studies conducted by Ram Asrey and Shukhla (2003) and fruit weight with fruit diameter reported by Pandey and Bist (1998), and, fruit weight with yield in ber by Bisla and Daulta (1987). Fruit volume also exhibited highly positive significant correlation with rind weight, juice content, fruit set, number of fruits/plant and gross fruit yield. Significant negative correlation was observed between acidity and TSS/ acid ratio. This indicated that increase in TSS/acid ratio was associated with reduction in acidity. The trait of juice content showed positive significant association with fruit set, number of fruits/plant and gross fruit yield. Highly significant association was observed between fruit set and number of fruits/plant and gross fruit yield and between number of fruits/ plant and gross fruit yield. Correlation studies in strawberry by Verma *et al* (2002) showed positive association of fruit weight with fruit diameter and fruit volume.

Path coefficient analysis was performed to assess direct and indirect effects of different characters on gross fruit yield (Table 2). Even though correlation analysis can quantify the degree of association between two characters, it does not provide reasons for such an association. Thus, a non-significant correlation coefficient value cannot be taken to imply absence of functional relationship between the two variables. Path coefficient analysis reveals this by breaking the total correlation coefficient into components of direct and indirect effects.

The maximum positive direct effect (Table 2) on gross fruit yield was through number of fruits/plant (0.587) followed by fruit weight (0.552), fruit volume increase (0.202), fruit set (0.131) and days to first flower opening (0.104). These results are in consonance with those of Baiyeri and Ortiz (1995) who reported that yield was more closely related to number of fruits/plant in banana.

Direct positive effect of fruit weight on yield in ber has been reported by Bisla and Daulta (1987). Fruit weight and rind thickness also exhibited highest and lowest positive direct effects, respectively. These results get support from earlier findings of Chaudhary and Singh (1998) who also reported similar effects in nut weight and nut thickness on kernel yield in apricot. Fruit weight, fruit diameter, fruit volume and fruit set had the highest positive direct effects via number of fruits/plant. The traits of fruit diameter, acidity, plant spread and TSS/ acid ratio imparted negative direct effect on gross fruit yield. Residual effect at the genotypic level was found to be slightly lower than at the phenotypic level. High magnitude of residual effect at phenotypic level indicated limitations of characters included in the present study which needs to be supplemented by more morpho-physiological traits so as to describe the whole range of variation (Table 3).

Keeping in view the estimation of association and path coefficient analysis towards gross fruit yield, selection should be practiced on the basis of number of fruits/plant and fruit weight as it had the highest positive direct effect. Results of the present study indicate that fruit weight, fruit diameter, fruit volume, juice content, fruit set and number of fruits/plant have significant positive correlation with gross fruit yield. Therefore, these main characters contributing towards gross fruit yield are ideal criteria for selection for yield in pomegranate.

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