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Genetic variability studies in pomegranate

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ABSTRACT

Genetic variability studies in 23 diverse genotypes including four mutant lines of pomegranate revealed higher genetic variability for most of the biochemical and morphological traits studied. High magnitude of coefficient of variability (phenotypic and genotypic) was observed for fruit and aril traits characters like fruit weight, fruit volume, fresh weight of 100 arils, dry weight of 100 arils, total aril weight and biochemical traits like titratable acidity, while low to moderate level of variation was observed in total soluble solids (TSS), pH and seed parameters like seed length and width. High heritability coupled with high magnitude of genetic advance was recorded for most of the characters *viz.* fruit weight, fruit volume, peel weight, aril weight, total no. of arils and titratable acidity. Whereas, comparatively lower heritability accompanied by low genetic advance was exhibited by characters like rind thickness, TSS, fruit juiciness and fruit diameter.

Key words: *Punica granatum*, morphological & biochemical traits, diverse, heritability, genetic advance.

INTRODUCTION

Pomegranate (*Punica granatum* L.), one of the oldest and beloved cultivated species of fruit crops, is a predominant member of family Lythraceae and is commercially grown for its fully luscious grains called 'arils' which constitute about 55-60% of the total fruit weight and consists of about 75-85% juice and 15-25% seeds (Al-Maiman and Ahmad, 1). The optimum growth conditions for pomegranate exist in Mediterranean-like climates which include long exposure to sunlight; mild winters with minimal temperatures not lower than 12°C; and dry hot summers without rain during the last stages of the fruit development (Levin, 4). In India, it thrives well in hot dry summer and cold winter, performing best under irrigated conditions. Pomegranate fruits are widely consumed fresh or processed into juice, syrup, jams and wine (Poyrazoglu *et al.*, 14). The concentrated juice and other plant parts of pomegranate bear properties like anti-oxidant, anti-inflammatory and anti-atherosclerotic against diseases like osteoarthritis, prostate cancer, heart diseases and even the deadly disease like HIV-1. Despite this, pomegranate culture has hitherto been restricted and is often considered as a minor crop. In order to exploit the full potential of this miraculous plant, a systematic effort aimed at the genetic improvement of this crop would be a paramount. Improvement of any crop, to a great deal depends upon the magnitude of genetic variability present among different characters and the extent to which these characters are transmitted from one generation to the next. Since, most of the yield and quality attributing traits are governed by polygenes and are highly influenced by environmental conditions, it is often difficult for a breeder to discern whether the observed variability is heritable or not. This information to a great extent decides the efficacy of selection and hence, in order to enhance the precision of selection, it becomes inevitable to partition the overall genetic variability into its heritable and non-heritable components. An attempt has thus, been made to estimate the genetic variability components in the pomegranate germplasm for the economic traits including morphological and biochemical components and thereby identify promising types depending on their performance under Karnataka conditions.

MATERIALS AND METHODS

Plant material consisting of 23 pomegranate cultivars including four mutant lines were used for the present investigation *viz.* Amlidana, Bhagwa, CO-1, Dholka, Early Bhagwa, G-137, Ganesh, Kabul Yellow, Kaladagi Local, KRS, Mridula, P-23, P-26, Phule Arakta, Ruby, Super Bhagwa, Tobesto, Wonderful, Yercaud and mutant lines; UHSP-23, UHSP-57, UHSP-81, UHSP-125. The experiment was carried out at University of Horticultural Sciences (UHS), Bagalkot, Karnataka in a Randomized Block Design with three replications during the year

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2016-2017. Nine fruits per genotype were used in three replications (three fruits per replication; one tree- one replication) and observations were recorded for 21 characteristics *viz.* fruit weight (g), fruit length (mm), fruit diameter (mm), fruit volume (cm^3), fresh wt. of 100 arils, dry wt. of 100 arils, moisture %, crown length (mm), peel weight (g), aril weight (g), total number of arils/fruit, aril length (mm), aril width (mm), seed length (mm), seed width (mm), rind thickness (mm), TSS (°Brix), ascorbic acid (mg/100g), titratable acidity (%), pH of the juice and fruit juiciness % (per 100gm aril wt.). For recording the observations, fruits of hasta-bahar flowering (October-November) were retained and harvested during February-April, 2017. Physico-chemical characteristics were recorded on three randomly selected fruits from each replication. The data were subjected to Analysis of Variance (ANOVA) and genotypic and phenotypic coefficients of variability, heritability in broad sense and genetic advance as per cent of mean, were computed by standard statistical procedures (Johnson *et al*., 2)

RESULTS AND DISCUSSION

Significant differences were recorded between genotypes for all morpho-pomological characteristics based on analysis of variance (ANOVA) at 1% level of significance (Table 1). Mean values of the characters studied, exhibited considerable variations between genotypes (Table 2 a & b). Wide range of variability has also been reported in pomegranate for various traits by Manohar *et al.* (5) and Pandey and Bist, 12.

With regard to fruit parameters like weight, volume, length, diameter and peel weight, Ganesh was found to be the most superior over other genotypes with significantly higher values for all the afore mentioned traits *viz*., 505.00 g, 527.78 cm3, 112.35 mm, 95.87 mm, and 192.44 g respectively. Bhagwa, the most popular variety of India, especially in the northern Karnataka, was found to have an average fruit weight of 285.33 g, significantly lower than its improved clones Early Bhagwa (350.22 g) and Super Bhagwa (306.44 g). Variation in fruit weight; a major yield attributing trait was huge which was in accordance with earlier reports regarding fruit

Table 1. Analysis of Variance (ANOVA) for morphological and biochemical traits in pomegranate.

Sl. No.	Characters	Mean Sum of Squares			F Cal	
		Replication (2)*	Treatment (22)*	Error (44)*	Replication	Treatment
1	Fruit weight (g)	1817.21	35307.54	332.26	5.46	106.26***
2	Fruit length (mm)	8.93	966.86	21.97	0.40	44.008***
3	Fruit diameter (mm)	0.85	584.91	33.81	0.00	17.29***
4	Fruit volume (cm^3)	854.28	37516.31	441.99	1.90	84.88***
5	Fresh wt. of 100 arils	9.98	236.20	3.03	3.29	77.82***
6	Dry wt. of 100 arils	0.09	16.21	0.05	1.90	341.06***
7	Moisture %	4.06	85.36	2.43	1.70	35.11***
8	Crown length (mm)	0.54	30.10	2.13	0.30	14.15***
9	Peel weight (g)	23.93	4839.65	32.89	0.70	147.13***
10	Aril weight (g)	1648.50	15070.67	379.13	4.35	39.75***
11	Total No. of arils/fruit	9017.58	164807.52	1805.40	4.99	91.28***
12	Aril length (mm)	0.28	5.85	0.23	1.20	25.64***
13	Aril width (mm)	0.41	6.65	0.33	1.20	19.88***
14	Seed length (mm)	0.71	1.83	0.11	6.34	16.22***
15	Seed width (mm)	0.13	0.15	0.06	2.10	2.43**
16	Rind thickness (mm)	0.98	2.09	0.43	2.30	4.90***
17	TSS (°Brix)	0.94	11.01	0.50	1.90	21.83***
18	Ascorbic acid (mg/100g)	5.48	144.07	6.66	0.80	21.62***
19	Titratable acidity (%)	0.00	0.18	0.00	0.80	172.25***
20	pH of the Juice	0.01	0.31	0.01	1.30	28.38***
21	Fruit juiciness % (per 100 g aril wt.)	10.79	381.42	16.97	0.60	22.47***

Number in parenthesis represents degrees of freedom, ***significance at 99.99% confidence level

Table 2(a). Mean values for individual morphological and biochemical traits of different pomegranate genotype.

Treatment	Fruit weight (g)	Fruit Length (mm)	Fruit diameter (mm)	Fruit Volume (cm3)	Fresh wt. of 100 arils	Dry wt. of 100 arils	Moisture %	Crown length (mm)	Peel weight (g)	Aril Wt. (g)	Total no. of arils/ fruit
Amlidana	187.56	70.57	72.80	189.44	32.55	8.03	75.33	20.05	34.00	153.56	317.44
Bhagwa	285.33	90.12	76.33	260.56	24.67	5.48	77.79	10.77	95.89	189.44	656.11
CO-1	148.65	59.24	65.97	115.00	22.50	5.86	73.96	13.06	65.00	83.65	320.33
Dholka	207.50	71.16	75.99	231.67	20.67	4.14	79.97	19.44	67.00	140.50	685.33
Early Bhagwa	350.22	100.34	85.70	358.33	32.33	7.34	77.30	15.13	121.56	228.67	710.00
G-137	227.03	67.07	73.50	235.00	22.33	5.61	74.88	19.04	95.00	132.03	559.67
Ganesh	505.00	112.35	95.87	527.78	46.89	9.62	79.48	12.83	192.44	312.55	1077.89
Kabul Yellow	134.44	61.37	64.61	141.95	30.00	7.59	74.70	13.30	45.00	89.44	283.00
Kaladagi Local	94.70	55.44	57.44	105.00	17.17	4.05	76.41	15.83	31.67	63.03	351.83
KRS	186.10	67.03	68.40	151.67	14.67	3.53	75.94	12.63	50.33	135.77	574.33
Mridula	96.93	50.52	56.55	113.33	16.67	3.35	79.90	12.61	30.00	66.93	330.33
P-23	134.89	59.39	61.98	112.11	32.22	6.79	78.93	13.20	53.89	81.00	465.22
P-26	179.78	67.35	69.20	182.28	36.44	6.59	81.92	13.74	79.22	100.56	383.37
PhuleArakta	374.22	94.50	86.41	377.78	32.22	5.91	81.66	8.92	118.67	255.55	767.78
Ruby	135.56	61.77	64.54	139.17	15.53	2.54	83.64	19.36	54.67	80.89	499.78
Super Bhagwa	306.45	97.86	94.14	313.89	30.56	5.54	81.87	13.60	110.89	195.56	671.89
Tobesto	225.60	72.00	67.50	279.67	35.00	7.19	79.46	12.80	70.00	155.60	231.33
UHSP 23	56.01	47.06	45.85	62.00	15.01	1.70	88.67	10.48	24.33	31.67	168.67
UHSP 57	145.76	52.96	54.25	148.33	23.98	1.62	93.22	12.51	38.67	107.10	187.67
UHSP 81	79.87	47.41	42.43	96.67	11.45	1.70	85.15	10.89	30.33	49.54	157.67
UHSP 125	71.50	53.93	51.43	93.33	16.97	1.15	93.22	13.78	29.00	42.50	150.67
Wonderful	202.67	67.72	76.60	196.67	32.00	6.65	79.22	18.81	80.67	122.00	502.33
Yearcaud	170.22	64.84	71.18	173.61	25.45	5.33	79.06	16.31	58.78	111.44	382.67
C.D.	30.10	7.74	9.60	34.71	2.88	0.36	2.57	2.41	9.47	32.15	70.15
SE(m)	10.52	2.71	3.36	12.14	1.01	0.13	0.90	0.84	3.31	11.24	24.53

Table 2(b). Mean values for individual morphological and biochemical traits of different pomegranate genotypes.

Treatment	Aril Length (mm)	Aril width (mm)	Seed length (mm)	Seed width (mm)	Rind thickness (mm)	TSS (°Brix)	Ascorbic Acid (mg/ 100g)	Titratable Acidity (%)	pH of the Juice	Fruit Juiciness % (per 100 g aril wt.)
Amlidana	9.63	6.72	5.89	3.04	1.44					
Bhagwa	8.11	4.51	6.84	3.32	3.66	15.56	50.00	1.09	2.53	54.89
CO-1	5.02	2.52	7.09	2.85	4.10	13.22	24.68	0.21	3.67	60.22
Dholka	9.03	5.32	7.76	2.48	3.42	14.53	26.79	0.05	3.54	58.37
Early Bhagwa	8.33	6.75	7.53	2.86	4.18	11.55	36.31	0.07	3.29	62.67
G-137	9.00	5.47	7.18	3.04	4.33	13.95	23.81	0.19	3.70	68.00
Ganesh	11.48	8.63	7.28	2.89	4.19	12.47	42.26	0.15	3.07	39.40
Kabul Yellow	9.74	6.99	5.59	2.62	2.73	15.53	25.60	0.19	3.99	66.22
Kaladagi Local	8.36	5.85	6.66	2.73	2.91	14.40	25.00	0.13	3.55	62.44
KRS	8.66	5.28	5.77	2.66	3.83	14.30	25.60	0.06	3.26	66.67
Mridula	8.72	4.81	7.52	2.89	4.06	12.50	29.17	0.05	3.49	61.52
P-23	9.56	6.84	6.73	3.21	2.29	10.52	25.00	0.08	3.54	56.00
P-26	10.08	6.38	6.61	3.11	3.90	14.83	26.78	0.06	3.26	64.00
Phule Arakta	8.08	4.59	6.84	2.76	2.18	13.67	26.19	0.07	3.40	59.67
Ruby	7.58	4.27	7.11	2.74	4.37	14.75	25.59	0.18	3.78	72.44
Super Bhagwa	9.81	7.14	6.61	2.92	3.85	9.62	20.24	0.13	3.90	71.55
Tobesto	9.85	8.00	6.77	3.25	4.30	12.55	22.02	0.18	3.70	61.33
UHSP 23	6.41	3.75	4.85	2.88	2.66	15.55	23.81	0.06	3.55	41.54
UHSP 57	7.11	4.17	4.85	2.60	2.58	11.65	22.04	0.42	3.34	29.07
UHSP 81	7.46	4.76	6.02	3.13	2.46	11.13	22.27	0.46	3.35	52.07
UHSP 125	8.48	4.81	6.32	3.10	2.96	12.86	22.26	0.64	3.13	50.65
Wonderful	10.35	7.57	6.82	2.97	3.73	12.44	23.84	0.47	3.64	46.95
Yearcaud	8.82	5.69	6.86	3.07	3.89	17.95	29.76	0.12	3.59	77.33
C.D.	0.79	0.96	0.55	0.41	1.08	12.43	29.83	0.12	3.02	60.00
SE(m)	0.28	0.33	0.19	0.14	0.38	1.17	4.26	0.05	0.17	6.80

weight by Tehranifar *et al*. (17). Zamani *et al.*, 18 and Khadivi-Khub *et al.* (3) also observed almost same trend for fruit weight ranging from 45.56–374.12 g and 69.77 to 341.91 g respectively, while Sarkhosh *et al.* (15) reported fruit weight 165–376 g for cultivated pomegranates. Fruit size is considered to be an important trait for fresh market trade and the variation of fruit weight is mainly influenced by the genotype but pedo-climatic conditions may also have an important role to play (Tehranifar *et al.*, 17). With regard to fruit volume Mir *et al.* (9) reported the range of 100.28-237.62 cm^3 with a mean value of 174.30 cm^3 for pomegranate cultivars under the Karewa belts of Kashmir which is lower than what recorded in the present study. The total no. of arils per fruit was also found wider than that reported by Mir *et al.* (9) *i.e.* 275.88-546.94, indicating the suitability of the varieties of the present investigation for improvement of this trait.

For aril parameters too, a great variation was observed among the genotypes in terms of wider range. The highest aril weight was recorded for Ganesh (312.55 g) followed by Phule Arakta (255.55 g), while the lowest was for UHSP 23 (31.67 g) followed by UHSP 125 (42.50 g). Total no. of arils/ fruit, aril length and aril width were also highest for Ganesh being 1,077.89, 11.48 mm, 8.63 mm respectively. However, unlike the weight of aril, the lowest no. of arils per fruit was recorded for UHSP 125 (150.66) followed by UHSP 81 (157.67), while aril length and width were lowest for CO-1 being 5.02 mm and 2.52 mm respectively.

With regard to biochemical parameters, cultivar Amlidana showed a mean ascorbic acid content of

50.00 mg/g and mean titratable acidity of 1.09%, highest among all the genotypes while its pH was 2.53, the lowest among all, indicating highly acidic nature of this cultivar. Variation in fruit weight, a major yield attributing trait, ranged from 56.01-505.00 g with very high heritability (h^2) value of 97.23% suggesting the amenability of this trait for improvement. Fruit volume and total no. of arils per fruit for the different genotypes ranged from 62.00-527.78 cm^3 and 150.67-1077.89 respectively.

Pomegranate arils contain juice, pulp, and the woody part rich in raw fibres and different other compounds, but from taste point of view, one of the most important traits is TSS of the arils. TSS for different genotypes ranged from 9.62 to 17.95 °Brix with an average of 13.39 °Brix. The range and average TSS values for the genotypes under study are almost similar to what reported for Spanish cultivars (Martinez *et al.,* 6). However, different ranges have also been reported in some previous studies, *viz*., 14.00–16.80°Brix in Spain (Melgarejo *et al.,* 8) and 13.56-15.77°Brix in India (Mir *et al.,* 13). These differences can be attributed not only to the different accessions but also to environmental conditions and harvesting times (Tehranifar *et al*., 17).

The estimates of heritability determine the effectiveness with which the existing genetic variability could be exploited for selection based on phenotypic expression (Johnson *et al*., 2). A perusal of data depicted in Table 3 revealed that the phenotypic coefficient of variation (PCV) was higher than its corresponding genotypic coefficient of variation (GCV) for all the traits as expected due to the influence of environment. Also, a high magnitude of coefficient of variability (phenotypic and genotypic) was observed for fruit and aril traits like fruit weight, fruit volume, fresh and dry weight of 100 arils, total aril weight and biochemical traits like titratable acidity (%), while low to moderate level of variation was observed in TSS, pH and seed parameters like seed length and width. Furthermore, the estimates of heritability in broad sense was observed to be higher (>90 per cent) for traits like fruit weight, fruit volume, fresh wt. of 100 arils, dry wt. of 100 arils, peel weight, total no. of arils/fruit and titratable acidity. Among the traits analysed, highest heritability of 99.13% was recorded in dry wt. of 100 arils followed by titratable acidity with 98.28%, while, lowest was observed for seed width (32.28%) (Fig. 1). By comparing the genetic advance as per cent mean (GAM) among the morphological traits, the highest GAM was observed for peel weight (119.05g) followed by fruit volume (112.38 cm^3, fruit weight (111.95g) and aril weight (109.06g). Among the biochemical traits, the highest GAM was exhibited by titratable acidity (223.56%) while the lowest values of GAM among morphological and biochemical traits were observed for seed width (6.83 mm) and pH of the juice (17.94) respectively (Table. 3). The results pertaining to phenotypic coefficient of variation (PCV) and its corresponding genotypic coefficient of variation (GCV) for all the traits suggests a better opportunity for their improvement through selection owing to the higher magnitude of the genotypic coefficient of variations for the afore mentioned traits. Wide range of variability in tree and fruit characters has also been reported by Meena *et al.* (7); Singh *et al.* (16) and Mir *et al.* (9) in pomegranate. The estimates of heritability in broad sense recorded by us is similar to that reported by Mir *et al.* (9) for fruit weight, fruit volume, number of seeds per fruit and aril weight. Mir *et al.* (10) also found high heritability for plant height, fruit volume, fruit set percentage, acidity, gross fruit

Table 3. Genetic variability and heritability for morphological and biochemical traits evaluated for different pomegranate genotypes.

Sl. No.	Traits	GCV (%)	PCV (%)	h^2b.s (%)	GAM
1	Fruit weight (g)	55.11	55.89	97.23	111.95
2	Fruit length (mm)	25.64	26.52	93.48	51.07
3	Fruit diameter (mm)	19.75	21.49	84.46	37.38
4	Fruit volume (cm^3)	55.52	56.51	96.55	112.38
5	Fresh wt. of 100 arils	34.53	35.2	96.24	69.78
6	Dry wt. of 100 arils	45.52	45.72	99.13	93.35
7	Moisture %	26.88	28.04	91.92	53.09
8	Crown length (mm)	21.34	23.65	81.43	39.67
9	Peel weight (g)	58.38	58.98	97.99	119.05
10	Aril weight (g)	54.95	57.04	92.81	109.06
11	Total No. of Arils/fruit	51.38	52.22	96.78	104.12
12	Aril length (mm)	15.77	16.7	89.15	30.66
13	Aril width (mm)	25.52	27.47	86.29	48.83
14	Seed length (mm)	11.48	12.56	83.54	21.61
15	Seed width (mm)	5.84	10.27	32.28	6.83
16	Rind thickness (mm)	21.98	29.22	56.57	34.05
17	TSS (°Brix)	13.98	14.95	87.41	26.92
18	Ascorbic Acid (mg/100g)	24.75	26.49	87.3	47.64
19	Titratable Acidity (%)	109.47	110.42	98.28	223.56
20	pH of the Juice	9.17	9.66	90.13	17.94
21	Fruit Juiciness % (per 100 gm aril wt.)	18.88	20.15	87.75	36.42

yield, rind weight and number of fruits/plant. The results obtained are also in close agreement with findings of Meena *et al.* (7); Pandey and Bist (12). High heritability in broad sense signifies that large proportion of phenotypic variance is attributed to the genotypic variance and hence the traits are less influenced by the environment enabling the plant breeders to base the selection programme on phenotypic performance. Moreover, the high genetic advance indicates that these traits could be improved to a considerable extent while the lower values signify that these traits could not be improved by altering the selection strategy such as marker assisted selection which relies mostly on the genotype.

In the present study, high heritability was found to be associated with high genotypic advance for most of the characters *viz.* fruit weight, fruit volume, peel weight, aril weight, total no. of arils and titratable acidity. High heritability coupled with high genetic advances have also been reported by Navjot *et al.* (11) in ber in traits like fruit weight, pulp stone ratio, total soluble solids and fruit yield per plant. Panse and Sukhatme (13) emphasised that if character is governed by additive gene action, both heritability and genetic advances would be high. Some of the characters exhibited comparatively lower heritability accompanied by low genetic advance *viz.* rind thickness, TSS, fruit juiciness, fruit diameter *etc.* indicating that dominance or epistatic effects are of considerable value for these characters and hence little improvement in these characters is possible through phenotypic selection. Johnson *et al.* (2) accentuate heritability estimates in conjunction with genetic advance to be more helpful in predicting its resultant effect from selecting the best individuals.

In conclusion, the present investigation illustrated the existence of wide range of variations for most of the characters among the pomegranate genotypes, providing opportunities for genetic gain through selection or hybridization. Fruit weight, fruit volume, peel weight, aril weight, total no. of arils and titratable acidity exhibited high heritability along with high genetic advance emphasizing that further improvement could be brought about by selection. Since these characters have significant contribution towards the yield potential of pomegranate, they can be ideal economic traits for selection of pomegranate cultivars for productivity.

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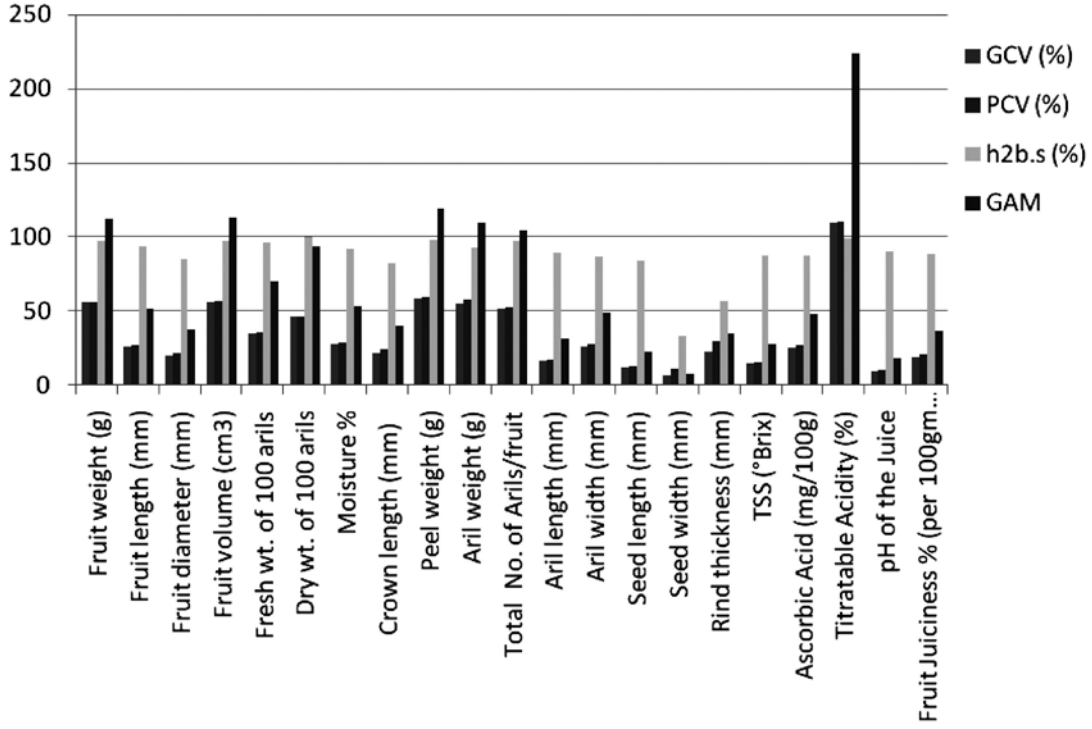

Fig. 1. Genetic variability and heritability of 21 traits of pomegranate genotypes.

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