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Divya Mehta

Department of TIGR, College of Forestry, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Tara Gupta

Department of TIGR, College of Forestry, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Correlation and factor analysis of quantitative traits of wild pomegranate in Himachal Pradesh

Divya Mehta and Tara Gupta

Abstract

The aim of this research was to carry out correlation and factor analysis of quantitative traits of four wild pomegranate provenances viz., Narag, Wagnaghat, Jonaji and Nauni, each comprised of three genotypes. Sixteen quantitative traits of leaves, flowers and fruits of wild pomegranate were used for statistical analysis. Results demonstrated significant variations among different provenances for all quantitative traits except leaf length, leaf breadth and leaf petiole length. Narag provenance revealed highest value for most of the traits viz., leaf area (5.46 cm²), flower petal length (20.16 mm), fruit length (5.61 cm), fruit breadth (5.48 cm), fruit rind thickness (3.32 mm), fruit fresh weight (78.61 gm), fruit rind weight (35.45 gm), fruit aril weight (43.16 gm) and no. of arils per fruit (294.82 gm). It was found that leaf length was in positive correlation with several fruit characteristics viz., fruit length ($r = +0.826$), Fruit breadth ($r = +0.745$), fruit fresh weight ($r = +0.735$), fruit rind weight ($r = +0.650$), fruit aril weight ($r = +0.725$) and no. of arils per fruit ($r = +0.623$). The characteristics of the leaves and fruits provided the main factor, confirming 42.57% of the total variance, which must be taken into consideration when distinguishing between wild pomegranate genotypes.

Keywords: wild pomegranate, correlation analysis, factor analysis

Introduction

Wild pomegranate (*Punica granatum* L., Punicaceae) is an ancient fruit tree, formerly known as *Malum granatum*. The species is native to Central Asia, but it is also grown in different geographical regions due to its high adaptivity to a wide range of climatic and edaphic conditions (Morton, 1987) [4]. In India wild pomegranate grows particularly in the mid-hill regions of Jammu and Kashmir, and Himachal Pradesh (Parmar and Kaushal, 1982) [6].

Wild pomegranate is a small to medium sized tree characterized by presence of multiple trunks and bushy appearance. Height of tree ranges from 3 to 9 meters. Stem is thorny, hard and light yellow in colour. The young branches which arise from the vegetative growth of the recent year are numerous, thin and quadrangular. Leaves are opposite, lanceolate, shining from above and often clustered on arrested branchlets. Leaves shed during November to December and new light red leaves starts appearing in the middle of March. Flowers occur about one month after bud break on newly developed branches of the same year. Flowers can appear in solitary, pairs or clusters and are sessile, bracteate, complete, actinomorphic and persistent. Fruiting starts to appear from 1st week of August and lasts till the end of September. Fruits are berry-like with a leathery rind enclosing many seeds. Seeds are angular with a fleshy aril which constitutes the edible part and colour of arils varies from red to pinkish white.

Estimation of the correlations between quantitative characters provides aid to build selection strategies (Falconer & Mackay, 1996) [1]. Several researchers reported that fruit characteristics such as peel thickness positively correlated with diameter of calyx and fruit weight with fresh and dry aril weight (Yazici and Sahin, 2016; Meena *et al.* 2009; Zamani *et al.* 2006) [2, 3, 7]. Morphological characters are used as markers for describing and classifying the germplasm, evaluation of disease susceptibility and for selection of parents in breeding program (Karimi *et al.* 2009) [2]. When there is large number of morphological characters, statistical method such as cluster analysis is used. Therefore, the objective of this research was to study the correlations between quantitative traits of wild pomegranate in order to determine their implications for breeding.

Materials and Methods**Study area**

Four wild pomegranate provenances viz., Narag, Wagnaghat, Jonaji and Nauni, each comprised of three genotypes, were used for evaluation of quantitative traits in Himachal Pradesh (Figure 1).

Corresponding Author:**Divya Mehta**

Department of TIGR, College of Forestry, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Quantitative traits

Sixteen quantitative traits of leaves, flowers and fruits of wild pomegranate were used for statistical analysis. Trait studied were leaf length (cm), leaf breadth (cm), leaf area (cm²), leaf petiole length (cm), flower sepal length (mm), flower petal length (m), no. of flower stamen, fruit length (cm), fruit breadth (cm), fruit rind thickness (mm), fruit fresh weight (gm), fruit rind weight (gm), fruit aril weight (gm), no. of arils per fruit, 100 fruit arils weight (gm) and 100 fruit seeds weight (gm).

Analysis of variances

The experiment was conducted in Randomized Block Design (RBD) with five replications using standard statistical procedure as described by Panse and Sukhatme (1967) [15]. Critical difference was calculated using following formula:

$$CD_{0.05} = SE_d \times t_{0.05} \text{ (error degree of freedom)}$$

Where,

$CD_{0.05}$ = Critical difference at 5% level of significance

SE_d = Standard error of difference of mean ($\sqrt{\frac{2M_e}{r}}$)

$t_{0.05}$ = t (table) value at 5% level of significance

Correlation analysis

Pairwise Pearson correlations coefficient between sixteen quantitative traits of wild pomegranate were calculated using following equation:

$$\text{Pearson's correlation coefficient } (r_{x,y}) = \frac{COV_{x,y}}{\sigma_X \sigma_Y}$$

Where;

$COV_{x,y}$ = Covariance of X and Y

σ_X = Standard deviation of X

σ_Y = Standard deviation of Y

Factor analysis

Factor analysis was carried out using statistiXL software. It revealed the number of main factors and reduced the number

of effective characteristics to discriminate between genotypes.

Results and Discussion

Quantitative traits

Mean values of the studied quantitative traits showed large variations between the provenances (Table 1). All quantitative traits except leaf length, leaf breadth and leaf petiole length, showed significant difference between mean values of traits for given provenance. Narag provenance demonstrated highest value for most of the traits viz., leaf area (5.46 cm²), flower petal length (20.16 mm), fruit length (5.61 cm), fruit breadth (5.48 cm), fruit rind thickness (3.32 mm), fruit fresh weight (78.61 gm), fruit rind weight (35.45 gm), fruit aril weight (43.16 gm) and no. of arils per fruit (294.82 gm) (Table 1).

Correlation analysis

Pairwise correlations of quantitative traits were shown in Figure 2. It was found that several leaf traits were in positive correlation with fruit characteristics. Leaf length showed positive correlation with fruit length ($r = +0.826$), fruit fresh weight ($r = +0.735$), fruit rind weight ($r = +0.650$), fruit aril weight ($r = +0.725$) and no. of arils per fruit ($r = +0.623$). Fruit breadth was directly correlated with leaf length ($r = +0.745$), leaf breadth ($r = +0.639$) and leaf area ($r = +0.692$).

Factor analysis

Based on factor analysis, the characteristics of leaves, flowers and fruits accounted for 42.57% of the variance as the first main factor (Table 2). For each factor, a factor loading of greater than 0.65 was considered as being significant. For the first factor, characteristics including leaf length, leaf area, fruit length, fruit breadth, fruit fresh weight, fruit rind weight, fruit aril weight and no. of arils per fruit had a loading of more than 0.65 and defined 42.57% of the overall variance. The numbers of stamen and fruit aril weight were significant for the second factors with 20.27% of overall variance. The third factor with 11.37% of the overall variance contributed to traits such as fruit rind thickness and fruit seed weight. The fourth factor was leaf petiole length, which contributed 7.97% of total variation.

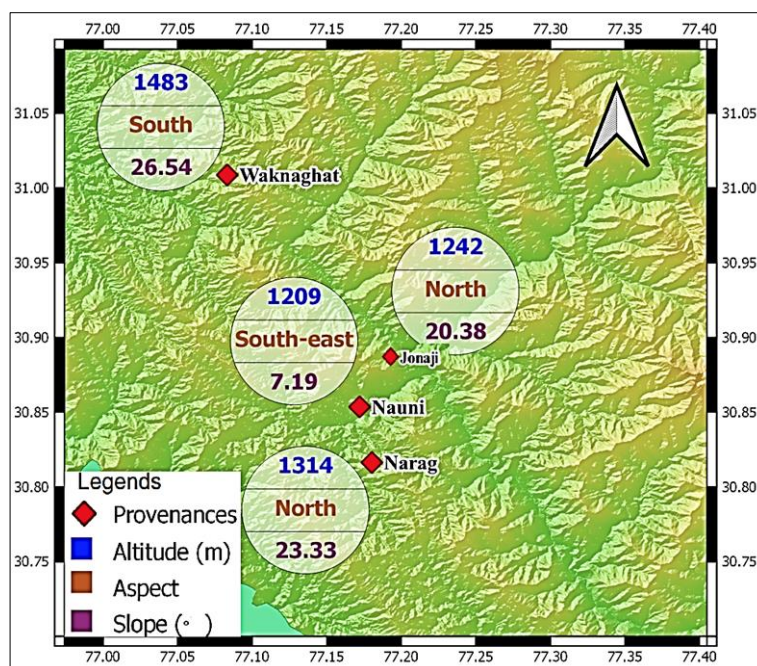


Fig 1: Topography of wild pomegranate provenances

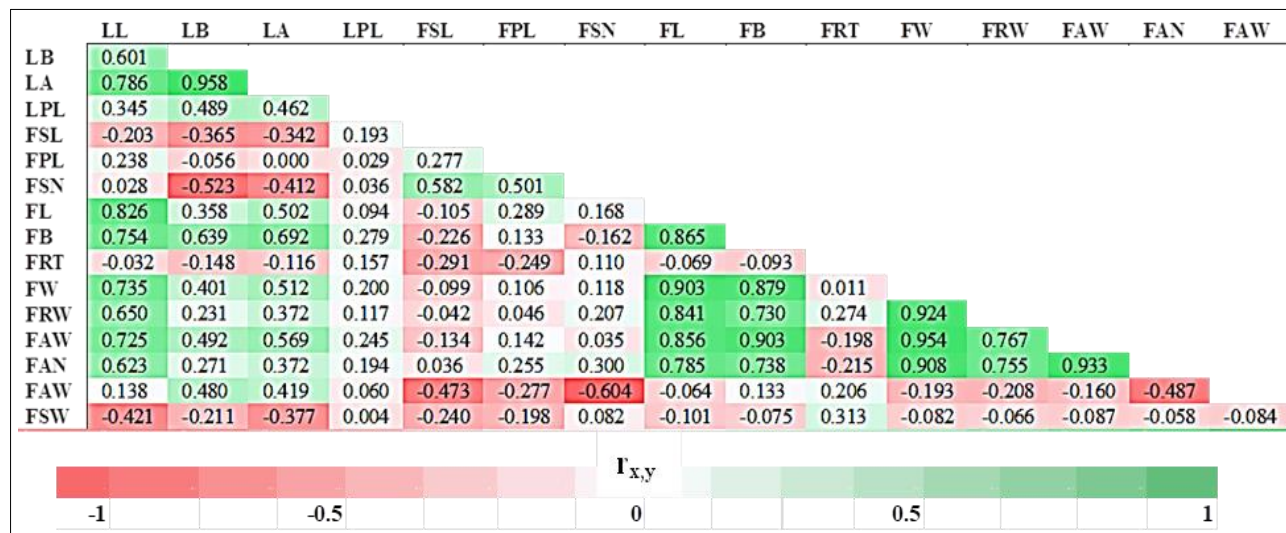


Fig 2: Correlogram of quantitative traits evaluated in wild pomegranate

Table 1: Comparison of quantitative trait means for wild pomegranate provenances

Traits	Leaf length	Leaf breadth	Leaf area	Leaf petiole length	Flower sepal length	Flower petal length	No. of flower stamen	Fruit length
Units	cm	cm	cm ²	m	mm	mm	—	cm
Abbreviations	LL	LB	LA	LPL	FSL	FPL	FSN	FL
Narag	4.41	2.16	5.46	5.10	9.69	20.16	306.53	5.61
Waknaghat	4.34	2.15	5.39	5.09	9.13	18.44	263.04	4.33
Jonaji	4.31	2.07	5.20	5.09	11.16	19.38	350.84	4.20
Nauni	4.32	2.15	5.37	5.09	9.24	18.71	263.73	4.11
CD 0.05	NS	NS	0.26	NS	0.41	0.75	18.31	0.36
Traits	Fruit breadth	Fruit rind thickness	Fruit fresh Wt.	Fruit rind Wt.	Fruit aril Wt.	No. of arils per fruit	100 Fruit arils Wt.	100 fruit seeds Wt.
Units	cm	mm	gm	gm	gm	—	gm	gm
Abbreviations	FB	FRT	FW	FRW	FAW	FAN	FAW	FSW
Narag	5.48	2.94	78.61	35.45	43.16	294.82	14.86	3.91
Waknaghat	4.59	3.02	54.96	25.78	29.18	209.44	14.22	3.85
Jonaji	4.26	3.05	47.60	23.52	24.07	195.61	13.06	3.91
Nauni	4.63	3.32	42.84	20.12	22.71	133.00	17.73	4.06
CD 0.05	0.32	0.38	8.37	4.36	5.22	41.07	2.40	0.57

Table 2: Factor analysis of quantitative traits evaluated in wild pomegranate provenances

Variable	Factor 1	Factor 2	Factor 3	Factor 4
Eigen value	6.811	3.244	1.819	1.275
% of Var.	42.569	20.273	11.371	7.966
Cum. %	42.569	62.843	74.214	82.179
LL	0.884	-0.098	-0.162	-0.106
LB	0.637	-0.641	-0.252	-0.135
LA	0.748	-0.548	-0.279	-0.131
LPL	0.334	-0.144	-0.185	-0.821
FSL	-0.174	0.642	-0.467	-0.302
FPL	0.184	0.481	-0.446	-0.054
FSN	-0.013	0.864	0.004	-0.319
FL	0.907	0.200	0.112	0.124
FB	0.937	-0.106	0.073	0.074
FRT	-0.087	-0.123	0.703	-0.534
FW	0.940	0.207	0.214	0.064
FRW	0.811	0.265	0.368	-0.043
FAW	0.942	0.139	0.070	0.141
FAN	0.841	0.433	0.060	0.118
FAW	-0.007	-0.849	0.001	-0.068
FSW	-0.212	0.069	0.706	-0.089

Conclusions

All quantitative traits except leaf length, leaf breadth and leaf petiole length, showed significant variation among different provenances. Narag provenance demonstrated highest value for most of the quantitative traits of wild pomegranate. It was found that leaf length was in positive correlation with several

fruit characteristics viz., fruit length, fruit breadth, fruit fresh weight, fruit rind weight, fruit aril weight and no. of arils per fruit. The characteristics of the leaves and fruits provided the main factor, confirming 42.57% of the total variance, which must be taken into consideration when distinguishing between wild pomegranate genotypes.

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